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IN SEARCH OF SPEECH INTELLIGIBILITY: THE CASE OF ENGLISH HIGH FRONT VOWELS

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Orientadora: Prof.ª Dr.ª Rosane Silveira

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ABSTRACT

Speech research has started to revolve around the issue of intelligibility in order to understand how certain phonological features affect communication among individuals from different first language backgrounds, who are also users of English as an L2. Thus, empirical research is vital to inform L2 pedagogy concerning what pronunciation aspects shall constitute the foci of instruction. Therefore, this study investigated the intelligibility of English high front vowels by focusing on (1) acoustic features of English high front vowels produced by Brazilians; (2) listeners' profiles (L2 proficiency and length of residence), and (3) word familiarity and word frequency. The speakers were 20 Brazilians who recorded sentences containing carrier words with the English high front vowels, /ɪ/ and /i/. To look at how these vowel categories were organized in the speakers' interlanguage and, thus, to select the tokens for the intelligibility test, normalized and non-normalized plots were obtained. To test for effects of spectral proximity on intelligibility, a criterion based on spectral proximity of the first formant was set. Intelligibility was measured through word transcription (Derwing & Munro, 2005), and the listeners were 32 users of English from 11 different L1 backgrounds. The acoustic analysis indicated that high front vowels were produced as equivalent vowels (Flege, 1995) and tended to overlap. Intelligibility results showed that the tense vowel was the most unintelligible one as it was generally mistranscribed by its lax counterpart. In a qualitative analysis, taking into consideration the carrier lexical item containing each vowel, it was found that other phonological processes present in the carrier words, such as consonant devoicing and palatalization, notably hindered intelligibility. Moreover, effects of listeners' L2 proficiency on intelligibility were tested and proficiency proved to be an important individual trait for speech intelligibility as the level of token intelligibility increased along with listeners' proficiency level. Listeners' length of residence in Brazil was investigated as an indicator of accent familiarity, but correlations indicated no significant results. In order to assess lexical frequency, the Corpus of Contemporary American English (COCA) was used. Listeners' familiarity with the lexicon used in the intelligibility test was investigated as well. Correlations revealed that the relationship between lexical frequency, lexical familiarity and correct responses in the intelligibility test were significant, demonstrating that the more frequent the lexical item, the more familiar and the more intelligible it was. In sum, results demonstrate that the high front vowels, when not distinguished, can pose a threat to intelligibility. In addition, there are other linguistic and listener-related variables that are likely to influence speech decoding, which, in investigations on intelligibility, can be examined at different levels (vowel, consonant, and word level).

Key-words: Speech intelligibility; English vowels; Brazilian speakers; Listeners' proficiency; Lexical frequency.

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RESUMO

A pesquisa que envolve a fala tem abordado a questão da inteligibilidade para entender como determinados aspectos fonológicos afetam a comunicação entre indivíduos que têm línguas-maternas diferentes, e que também usam inglês como uma segunda língua (L2). Assim, pesquisas empíricas são necessárias para informar o ensino, especialmente, no que tange aspectos da pronúncia da L2 que devem constituir o foco de instrução na sala de aula. Portanto, o presente estudo investigou a inteligibilidade das vogais altas anteriores do inglês focando (1) nas características acústicas das vogais altas anteriores do inglês produzidas por aprendizes brasileiros, (2) nos perfis dos ouvintes (proficiência da L2 e tempo de residência no Brasil), e (3) na familiaridade e frequência do léxico. Os falantes foram 20 estudantes brasileiros que gravaram sentenças contendo palavras com as vogais altas anteriores do inglês, /ɪ/ e /i/. Para observar como essas categorias vocálicas organizavam-se na interlíngua dos falantes e, assim, selecionar os dados para o teste de inteligibilidade, plotagens dos dados em versão normalizada e não-normalizada foram obtidas. Para testar os efeitos de proximidade espectral na inteligibilidade dessas vogais, um critério baseado na proximidade espectral do primeiro formante (F1) foi estabelecido. Inteligibilidade foi avaliada com o uso de transcrição ortográfica (Derwing & Munro, 2005), e os ouvintes foram 32 usuários de inglês de 11 línguas-maternas diferentes. A análise acústica demonstrou que as vogais altas anteriores do inglês foram produzidas como vogais equivalentes (Flege, 1995), e tendiam a sobrepor-se. Resultados concernentes à inteligibilidade indicaram que a vogal tensa foi mais ininteligível, pois era inadequadamente transcrita como a vogal frouxa. Em uma análise qualitativa, considerando o item lexical que continha cada vogal, observou-se que processos fonológicos presentes nessas palavras, tais como desvozeamento de consoantes e palatalização, afetaram consideravelmente a inteligibilidade da fala. Além do mais, efeitos da proficiência do ouvinte na L2 foram testados e proficiência demonstrou-se ser uma importante característica individual para aferição da inteligibilidade da fala, pois observou-se que o nível de inteligibilidade aumentava juntamente com o nível de proficiência do ouvinte. O tempo de residência dos ouvintes no Brasil foi investigado como um indicador indireto de familiaridade com sotaque, mas as correlações não indicaram resultados significativos. Para analisar frequência lexical, o *Corpus of Contemporary American English* (COCA) foi utilizado. A familiaridade dos ouvintes com o léxico utilizado no teste de inteligibilidade foi também observada. As correlações revelaram que a relação entre frequência lexical, familiaridade com o léxico, e respostas corretas no teste de inteligibilidade eram significativas, demonstrando que quanto mais frequente o item lexical, mais familiar e mais inteligível era esse item também. Em suma, resultados demonstram que as vogais altas anteriores, quando não distinguidas, podem influenciar negativamente a inteligibilidade. Não obstante, existem outras variáveis linguísticas e variáveis relacionadas ao ouvinte que estão propensas a influenciar na decodificação da fala que, em investigações referentes à inteligibilidade, podem ser observadas em diferentes níveis (vogal, consoante, e nível da palavra).

Palavras-chave: Inteligibilidade da fala; vogais do inglês; falantes brasileiros; proficiência do ouvinte; frequência lexical.

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LIST OF ABBREVIATIONS

AE – American English

BP – Brazilian Portuguese

BPSE – Brazilian Portuguese Speaker(s) of English

L1 – First Language/Mother Tongue

L2 – Second Language/Foreign Language

LF - Lingua Franca

LFC - Lingua Franca Core

LoR - Length of residence

NNS – Non-native Speaker(s)

NNSE – Nonnative Speaker(s) of English

NS – Native Speaker(s)

NSE – Native Speaker(s) of English

OPT – Oxford Proficiency test

RoF - Rank of frequency

RQ – Research question

SD – Standard deviation

SLA – Second Language Acquisition

SUMMARY

CHAPTER ONE
INTRODUCTION

1.1. Context of investigation

Speech intelligibility has started to receive attention in some areas of L2[1] phonological research. Research has taken up on speech features that are more likely to affect communication among individuals who have different L1s, given the increasing number of speakers of English worldwide, who currently use English as a lingua franca in their interactions. However, much is yet in need to be investigated concerning phonological aspects which are responsible for intelligibility in L2 interactions.

Intelligibility, a dimension used to assess L2 speech, has been little investigated in Brazil. To date, much of the research available has made use of native speakers (NS) to assess Brazilians' pronunciation, which might have overlooked crucial pronunciation aspects of Brazilian-Portuguese speakers of English (BPSE) (Jenkins, 2012). Research has also investigated the reactions of BPSE to speech of other non-native

[1] L2 is to be used as a cover term to account for any languages acquired after one's first language (L1).

speakers of English (e.g., Becker, 2013), thus, leading to a gap in the field, which needs studies on how intelligible BPSE speech is to other NNSE. There is a limited number of studies in which BPSE speech tokens were submitted to the reactions of L2 users from other linguistic backgrounds (Cruz, 2005; 2006; 2008; Cruz & Pereira, 2006; Schadech, 2013).

Research trends have revolved around the issue of intelligibility (along with comprehensibility and accentdness[2]), which has been pointed out as one of the main goals in L2 pronunciation teaching. Scholars have claimed that classroom-relevant research must be undertaken (Derwing & Munro, 2005) so that L2 phonology also attends to the listeners (Munro, 2011). One can envisage that when a relevant number of studies on intelligibility are provided, SLA practitioners and material-developers will be able to make informed decisions in relation to what is worth teaching in the L2 classroom. Given that little research on the issue of intelligibility has been conducted in Brazil, this study addresses pronunciation-based intelligibility problems of BPSE.

[2] Comprehensibility and accentedness are other dimensions used for evaluating L2 speech. Along with intelligibility, they are all conceived as independent measures. See Derwing and Munro (1997) for a discussion.

1.2. Objective and Research Questions

The general goal of the present study is to measure the intelligibility of English high front vowels produced by the BPSE. In order to reach a better understanding on intelligibility, this study also investigates listener-related variables which have been attested to influence this dimension. As a guide, the following research questions and hypotheses were set down. Their reasoning and the studies that motived their development are presented in Chapter 3.

RQ1: Which of the high front vowels produced by the Brazilian speakers causes more intelligibility problems at vowel level and at word level[3]?

H1: Both vowels will cause intelligibility problems at both levels.

RQ2: How do the F1 values of the high front vowels produced by the Brazilian speakers affect intelligibility?

H2: High front vowels with F1 values which are further from the mean of the native speakers, either one standard deviation below or above, will affect intelligibility the most.

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[3] Word-level is to account for intelligibility of the entire word, whereas vowel-level is to account for the intelligibility of the tested vowels that are inserted in these words. This is explained in detail in Chapter 3

RQ3: How are the listeners' proficiency level related to their performance on the intelligibility test, at both vowel and word levels?

H3: The higher the listeners' proficiency level, the better their performance on the intelligibility test.

RQ4: Does word familiarity correlate with lexical frequency and with listeners' performance on the intelligibility test?

H4: Word familiarity, lexical frequency and intelligibility test scores are correlated.

RQ5: How does the listeners' length of residence (LOR) correlate with their performance on the intelligibility test, at both vowel and word levels?

H5: Listeners who had been longer in Brazil will be more attuned to speakers' accent, and, thus, accent familiarity will positively influence listeners' performance on the intelligibility test.

1.3. Significance of the Study

In an attempt to better understand speech features that influence intelligibility, the present study investigates the intelligibility of BPSE high front vowels, and the impact that these vowels can have on intelligibility as measured by the reactions of NNSE from eleven different L1 backgrounds (see Section 3.4.1). In the controversial Lingua Franca core (LFC), Jenkins (2002) advocates that maintenance of contrast between long and short vowels can prevent language breakdowns. However, it is still blur if this assumption holds true when the intelligibility of BPSE speech is investigated.

Studies in Brazil have addressed a diverse array of issues related to the phonetic and phonological features of BPSE speech[4]. The dimensions of perception and production account for most of the literature available in the field. With respect to vowels, a number of studies on vowel acquisition, perception and production have as well been carried out (Baptista, 2006; Bion, 2007; Bion, Escudero, Rauber & Baptista, 2006; Nobre-Oliveira, 2007; Rauber, 2006; Rauber, Escudero, Bion & Baptista, 2005, to cite some). However, it is worthwhile to state that there has been only a handful of studies on intelligibility (many of them are small-scale pieces of research), and it seems that the intelligibility of vowels is yet to be investigated. Notwithstanding, research on intelligibility is in need of an endeavor towards the relationship between acoustic features and intelligibility, so that the field can be informed of the speech acoustic properties which are likely to influence speech decoding.

[4] See Silveira (2010) for a research timeline.

The present study also seeks to discuss complex issues related to intelligibility. One of these complex issues is the role of segmental level perception in L2 intelligibility, as this study examines if the high front vowel distinction is relevant for intelligibility when BPSE perform a sentence-reading test. In addition, an Applied Linguistic research design can provide empirical data to inform teacher education programs, so that teachers of English and SLA practitioners can be aware of how pronunciation teaching can be addressed in the classroom, and tailor instruction towards students' needs. Furthermore, it is of utter importance that intelligibility studies in Brazil focus on features likely to enhance speech intelligibility. Pronunciation teaching of these aspects then might be tackled as a fixed component in language syllabi and in the L2 classroom.

1.4. Organization of the Study

In the present study, Chapter 2 provides an overview of the most relevant literature regarding the issues of English as a Lingua Franca, and Intelligibility. Chapter 2 also describes BP and English vowel inventories, as well as how different L2 vowels can be assimilated into one category given the L1 influence. Chapter 3 addresses the method used in data collection and analyses, as well as all participants’ profiles. The research findings are reported and discussed in Chapter 4. At last, Chapter 5 draws on the main findings of the present study, its limitations and suggestions to warrant further research.

CHAPTER TWO
REVIEW OF LITERATURE

English has been recognized for quite a long time as the common language used internationally for various purposes, thus becoming the means of communication among individuals from different L1s (Graddol, 2006; Jenkins, 2006, 2012; Seidlhofer, 2005). Research on L2[5] speech has currently started to shift attention to phonological aspects of communication among NNSE which have an impact on their interactions. Given this myriad of L2 users of English from considerably diverse linguistic contexts, a hot discussion has been undertaken on what needs to be taught as concerns pronunciation. New concepts for assessing L2 speech arouse, such as intelligibility, comprehensibility, and accentdness (Derwing & Munro, 1997; 2005; Munro, 2008; Munro & Derwing, 1995; 2006; 2011; Munro et al., 2006), which now embody the L2 research niche along with the more traditional dimensions of perception and production.

Nonetheless, little research has been carried out in Brazil dealing with these new concepts. Becker (2013), Cruz (2004), and Schadech (2013) have heretofore developed studies examining aspects of L2 English spoken by Brazilians in relation to the concepts of intelligibility and comprehensibility. However, these studies have neither dealt with speech acoustic properties, leading to an existing gap on the relationship of the L2 speech acoustic features which

[5] L2 and ELF (English as a Lingua Franca) are conceived as independent terms in the present study. L2 is to account for any language acquired after one's first language (L1), whereas ELF must account for English used as a cross-boundaries means of communication among speakers who have different L1s.

affect its recognition, nor have they focused on vowel intelligibility as their main scope.

In pronunciation manuals and textbooks, the high front vowels are commonly taught with minimal pairs, for it is believed that not knowing how to produce the distinction between these vowels might lead speakers to miscommunication. Yet, it is still blur how not being able to distinguish between these two vowels can affect communicative efficiency among NNSE. Listener-oriented research appears to be paramount in this matter, as it can indicate how L2 vowels are recognized by language users from different L1 backgrounds, as well as it consistently sheds light on listener-related and speaker-related variables which play a role in determining the intelligibility of such vowels. Experimental acoustic studies also appear to be pertinent for providing insight on speech features which can strengthen or hinder intelligibility.

On the relationship of English as a Lingua Franca (ELF) and intelligibility, Jenkins (2002) advocates that speakers' traits could be enhanced by tailoring pronunciation instruction according to the LFC, rather than native-like models. When proposing the LFC, the author highlights some L2 phonological components to be kept for speakers to avoid language breakdowns[6], such as (1) most consonant sounds (except [θ] [ð]), (2) tonic or nuclear stress, (3) vowel length, and (4) non-permissible simplification of consonant clusters (Jenkins, 2002). The LFC presents results of empirical research conducted with

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[6]Refer to Jenkin's (2002) main core items (page 96 in her work).

speakers from different L1s, but it does not directly account for Brazilian learners' traits, and "the available evidence is very limited, based on a small sample of communication breakdowns across very few learners" (Derwing, 2008, p. 352). Therefore, to make intelligibility findings more generalizable, L2 speech research in Brazil is still in need of empirical evidence to broaden its findings regarding intelligibility, as "[…] the choices a pronunciation teacher makes should be based on factors that have been shown to influence intelligibility […] (Derwing, 2008, p. 351).

Having introduced the initial motivation for the present study, I shall now address the main concepts/areas of study which guide this piece of research, starting with the notions of Lingua Franca, intelligibility, and studies addressing this topic carried out in Brazil, which are then followed by a review of vowel intelligibility and vowel inventories. Furthermore, I report findings related to high front vowels from acquisition, perception and production studies with Brazilian participants. Last, the variables of the present study are discussed.

2.1 The notion of English as a Lingua Franca

In this study, the decision of recruiting listeners who speak an L1 other than English or Portuguese, and who also speak English as an L2, revolves around the issue of ELF. Intelligibility is therefore examined across different linguistic and cultural backgrounds, following current trends of research on L2 speech[7], and accounting for the concern voiced by Jenkins (2002) in regard to a research design on Applied Linguistics which operates with L2 speech features, instead of promoting the encouragement for L2 speakers to accept NSE norms of pronunciation. Jenkins (2002) claims that these norms[8] often have a negative effect on intelligibility for L2 speakers, simply because they are facts of NS pronunciation[9].

When it comes to defining ELF, its definitions usually refer to the language as a means of communication among speakers from different L1s. Interestingly, one might assert that the language has merged with the innumerable traits of its various users, in tune with Seidlhofer (2005), who remarks that "English is being shaped at least as much by its non-native speakers as by its native speakers" (p. 339). Seidlhofer (2005) defines ELF as "the means of communication among people from different language backgrounds across linguacultural boundaries" (p. 339). Firth (1996) presents it as "the contact language between persons who share neither a common native tongue nor a common (national) culture, and for whom English is the chosen language of communication[10]" (p. 240, adapted). Hülmbauer et al (2008) discuss that "ELF is emphatically not the English as a property of its native speakers, but is

[7] See Munro and Derwing (2011) for a research timeline that traces empirical bases of current approaches to L2 pronunciation, specially, to intelligibility.
[8] See Jenkins (2002) for a detailed discussion on these norms.
[9] However, insufficient empirical evidence has been provided for such claim.
[10] I consider Firth's definition appropriate given that the word "foreign" found in the excerpt "for whom English is the chosen *foreign* language of communication" is excluded. As NSE are to take part in ELF interactions, calling it "foreign" might be controversial.

democratized and universalized in the 'exolingual' process of being appropriated for international use" (p. 27). Similarly, Jenkins (2007) considers that ELF "does not fit neatly into pre-existing categories predicated on the tired old dichotomy of native/nonnative Englishes" (p. 414).

Jenkins (2012) draws attention to the fact that ELF also includes NS in its interactions. The author claims that NS of English need to acquire ELF, as they "need to be able to adjust (or accommodate) their habitual modes of reception and production in order to be more effective in ELF interactions" (Jenkins, 2012, p. 487). Hülmbauer et al (2008) also claim that NSE are frequently in disadvantage "due to their lack of practice in these processes and over-reliance on English as their L1" (p. 27).

To sum up, the purpose of dealing with ELF in this study is twofold: I intend to make ELF more familiar to Brazilian grounds, as this is an increasing field in L2 research, and a globalizing phenomenon which is gradually changing (Jenkins, 2011). Therefore, research in Brazil needs to be included in its route. Secondly, I as well intend to heighten the findings available on Brazilians learners' speech intelligibility so that this research dimension is not jeopardized in the Brazilian teaching context.

2.2 Defining *Intelligibility*

Intelligibility is a dimension used for evaluating L2 speech that has been proposed as one of the main goals of pronunciation instruction. Munro (2008) remarks that “rather than acquiring native-sounding oral output, L2 learners need intelligible speech, and the latter does not necessitate perfect formal ‘correctness’ (p. 213)”. Graddol (2006) states that “intelligibility is of primary importance, rather than native-like accuracy” (p. 87). Kennedy and Trofimovich (2008) assert that “students whose L2 production is not entirely native-like but who are able to communicate effectively are clearly successful L2 users” (p. 460).

As one of the factors which contribute to communication effectiveness, intelligibility is defined by Derwing and Munro (2009) as “the degree of a listener’s actual comprehension of an utterance” (p. 479). Different definitions on the term have been drawn by many other researchers (see discussion in Cruz, 2007). The one hereby presented clearly accounts for the interlocution between what is communicated by the speaker and what is actually understood/received by the listener, as “a comparison of the intended message with the received message is essential” (Munro, 2008, p. 202).

Literature has also conclusively shown how intelligibility differs from other relevant dimensions in the field. According to Derwing et al. (2007), comprehensibility refers to “the ease or difficulty with which a listener understands L2 accented speech” (p. 360). Assessing tasks on this dimension usually make use of a Likert scale to inform how easy or difficult a speech sample is. In addition, accentedness refers to “a listener’s perception of how different a speaker’s accent is from that of the L1 community” (Derwing & Munro, 2005, p. 385). This dimension seeks to evaluate listeners’ perception of accent in the L2, usually through a scalar scale that varies from “no accent” to “heavy accent”.

Other than exploring the level of ease or difficulty of a speech sample, or whether listeners are able to diagnose how accented speech samples are, the present study focuses mainly on the phonological traits that influence intelligibility of L2 speech.

When drawing on intelligibility assessment, Munro (2008) remarks that "the choice of a particular approach depends on the type of speech material that is available or that can be elicited, the kinds of demands that can be placed on listeners and speakers, and the specific research questions to be addressed" (2008, p. 201-2). Word transcription has been regularly used for intelligibility assessment as this method is seen an index of the speaker's intelligibility (Munro et al., 2006).

However, evidence garnered on transcription data provides only one perspective on intelligibility (Munro et al., 2006), as "there is no universal way of assessing it" (Munro & Derwing, 1995, p. 76). This method of assessing intelligibility fits well the present study as vowel intelligibility is assessed based on insolated word recognition, which allows the researcher to focus specifically on the use of a target vowel or word, taking into account the high front vowel contrast. Moreover, this experiment allows the researcher to observe the "extent to which a word or utterance is recognized at the level of finer acoustic-phonetic detail" (Moyer, 2013, p. 93), which is appropriate for dealing with the specificities of vowel intelligibility.

Research on intelligibility is still vital as "much more work must be carried out to determine whether listeners from diverse backgrounds share similar responses with regard to intelligibility" (Munro et al., 2006, p. 114). In some areas of Applied Linguistics, the function of such construct remains controversial. Moyer (2013) suggests that intelligibility should function at the level of suprasegmental accuracy (prosodic information). The author also advocates that "controlled tasks do not capture the dynamic qualities of intelligibility" (2013, p. 98). Moyer (2013) concludes that research interests should rely on the adjustments listeners make when a speaker is difficult to understand, and whether such adjustments correspond to communicative problems alone. Thus, the author sheds light on intelligibility as being negotiated in interactions. I consider Moyer's position relevant, but if only this is taken into account, results then are too limited. Research can profit from the many approaches to deal with intelligibility, at the segmental or suprasegmental level, or intelligibility in extemporaneous conversations. However, to deal with vowels in the present study, only segmental intelligibility will be looked at. Other approaches to speech intelligibility do not constitute the scope of the present study, and shall be addressed as limitations for further research.

To date, there have not been studies focusing specifically on how vowels can promote efficiency in L2 communication. In Brazil, the work by Cruz (2005, 2006, 2008, 2012a, 2012b) accounts for most of the research findings, many of them still descriptive, which are available in the field. Moreover, Becker

(2013), and Schadech (2013) have as well dealt with the issue of intelligibility. The most relevant aspects of these studies are reported in the next section[11].

2.3 Studies on Intelligibility in Brazil

Cruz has published a number of studies in which she investigated the intelligibility of BPSE. I shall now review Cruz's studies by firstly presenting all studies in which NSE were the judges for intelligibility (Cruz, 2005; 2006; 2008; Cruz & Pereira, 2006); and, then I present the studies in which there were no judges, but in which the author investigated pronunciation aspects which led to communication breakdowns (Cruz, 2012b; Reis & Cruz, 2010). The findings of these studies are presented last, as the pronunciation aspects that hindered intelligibility were overall similar (and these results are usually grouped by the researcher in her studies). Besides Cruz, Becker (2013) and Schadech (2013) have also developed studies investigating intelligibility. Their studies are reviewed last.

In a small-scale study, Cruz (2005) investigated the pronunciation of the word "comfortable" with stress falling on the third syllable [kʌmfəˈteibou]. The researcher examined the reactions of British NS to the intentionally mispronounced word, in which eight listeners (out of 14) did not comprehend what the speaker meant. Cruz (2006) investigated the intelligibility of Brazilian-

[11] Silva (1998) was excluded given the misconceptualization of the construct intelligibility. The author calls intelligibility what is actually conceived as comprehensibility.

accented-English to twenty-five British NS in a study in which listeners evaluated how intelligible the samples were, and also transcribed them. The researcher also interviewed the listeners in seek of more detailed descriptions of their reactions to the speech samples. Cruz (2008) explored how accent familiarity affects intelligibility. The researcher collected speech data from ten BP speakers of English and used them as stimuli with twelve NSE (10 American and 2 British). They rated intelligibility on a scale (which is actually comprehensibility), and were required to transcribe the stimuli. Similarly, Cruz and Pereira (2006) looked into the pronunciation aspects of *Letras* undergraduate students that hindered intelligibility according to the judgments of NSE (7 American and 1 British) who had been living where the study was carried out, and thus, were familiar with the speakers' accent. The listeners were required to transcribe the stimuli, identify words which they considered difficult to understand, and reason on why they considered such words difficult.

Cruz (2006) examined the intelligibility of English in informal interactions between a Brazilian, a Japanese, a German, and two Thai speakers. From the communication breakdowns the research mapped, she created distinct categories of pronunciation aspects which require attention, and correlated them to Jenkin's LFC, remarking that two (out of 4) of her categories are contemplated by the LFC (word stress, and consonants). Cruz (2012b) investigated which pronunciation aspects of English spoken by a Japanese hindered intelligibility the most according to the reactions of seven *Letras* undergraduate students. The research required the listeners to transcribe the reading passage they had listened to, identify words which they considered difficult to understand, and explain why they considered those words difficult. Finally, Reis and Cruz (2010) investigated pronunciation aspects which influenced intelligibility and led to miscommunication between three Brazilian and three French speakers of English. The researchers also correlated such aspects to the LFC, as proposed by Jenkins (2002), and concluded that "all the factors identified in the analysis refer to those included in the LFC" (2010, p. 53).

Generally, findings from Cruz's studies are mapped in the following categories[12]:

- **Word-stress**: stress falling either on the second or third syllable instead of falling on the first (e.g., 'vegetables' pronounced as [vəʒˈteibous]) hinders intelligibility;
- **Orthography influence:** the grapheme < u > pronounced as [u] instead of /ʌ/ (e.g., 'production' produced as [proˈdukʃən]) causes misunderstandings, as well as final /l/ pronounced as [w] (e.g., 'feel' pronounced as [fiw]), and [z] produced as [s] (e.g., 'mixes' produced as [ˈmɪkis]);
- **Consonants:** most NSE listeners, familiar and non-familiar with BP-accented-English, had problems understanding the

[12] All examples involving phonetic transcriptions were taken from Cruz's studies.

voiced fricative /ð/ produced as the voiced stop /d/ in ‘other’ [ˈʌdɛɾ]; and the voiceless fricative /θ/ produced as /f/, when combined with the omission of /ŋ/, e.g., ‘think’ produced as [ˈfĩk], also hindered intelligibility;

- **Vowels:** the sources of unintelligibility were the neutralization of the difference between tense and lax vowels (/i/ pronounced as [i]; and /ɪ/ pronounced as [i]; e.g., ‘live’ understood as “leave”;); the back vowel /ʊ/ produced as /u/ (e.g., ‘cooks’ pronounced as [kuks]; and final position /i/ pronounced as a reduced vowel (e.g., *many* pronounced as [mɛnⁱ];

Taking into account the results listed above, Cruz (2012a) discusses that these would be the priority in teaching pronunciation to Brazilians, according to her intelligibility phonological model. A poignant aspect in Cruz’s research is the fact that the speech traits considered unintelligibility sources were judged mostly by native speakers of English. Differently, Jenkins (2002) LFC accounts for interactions mostly among NNSE. Also, it has been evidenced that NNS nowadays outnumber NS (Crystal, 2003; Graddol, 2006). Therefore, interactions in ELF are more likely to happen among NNSE. Even though NSE are not and shall not be excluded from an ELF approach, it makes more sense to draw attention to intelligibility involving ELF users. Notwithstanding, many of the examples displayed above show that more than one type of mispronunciation occurs in a single word, which makes it difficult to decide whether a specific aspect or a combination of many is affecting intelligibility, which also draws attention to the need for more controlled studies on intelligibility.

Studies in which BPSE judged speech intelligibility of other NNSE have contributed considerably to modeling how BPSE react to L2 accented-speech. However, it is not fitting to mix up findings of unintelligibility as judged by NSE to findings of unintelligibility as judged by NNSE in the same categories. As previously discussed, Jenkins (2002) poses that NSE norms of pronunciation have a negative effect on intelligibility for L2 speakers, that is, L2 speakers have different needs when it comes to mispronunciation leading to unintelligibility. Therefore, both Cruz and Jenkins present relevant findings, but I shall maintain that they take somewhat different paths to raise awareness towards intelligibility.

Becker (2013) also carried out a study on intelligibility in Brazil. The researcher collected samples of different types of accented English from the *Speech Accent Archive,* and presented them to *Letras* undergraduate students. The stimuli used by the researcher encompassed American, Chinese, Japanese, and German accented English, which were chosen, as stated by Becker (2013), for being varieties frequently present in the commercial relations Brazil currently has. The listeners, Brazilian students, were required to perform three tasks: (1) listen to all the stimuli and report a percentage of how much they could comprehend, (2) listen to each stimulus and transcribe the missing words; (3) indicate the items which, according to their point of view, hindered intelligibility. The researcher prepared the paragraphs by splitting them in short sentences from which a number of words were removed. Then, the paragraphs were presented to the listeners, who should complete them with the missing words.

Concerning consonants, Becker (2013) reports that the fricatives /θ/ and /ð/ hindered intelligibility, and interestingly, this feature is not included in the LFC. The fact that these consonants may hinder intelligibility was also reported by Cruz (2012a), indicating that for BSE, this might constitute scope for future research with intelligibility[13]. Furthermore, the flap /ɾ/ also hindered intelligibility, along with consonant devoicing in final position (for instance, *big* pronounced as [bik]). Clusters, as seen in the LFC, also caused misunderstandings according to Becker's study, in words such as *Stella*, *snow*, and *spoons.*

When it comes to vowels, Becker (2013) advocates that temporal cues are important for vowel intelligibility. The high front vowel pair was misrecognized in her study (e.g., in the word *peas*, pronounced as [pɪz]). Similarly, vowel length is a feature included in the LFC, and mentioned by Cruz (2012a). Moreover, Becker (2013) discusses that vowel quality is an important characteristic for L2 intelligibility. The researcher presents cases where, for instance, *snack* was produced with the vowel [a], resulting in [snak], and in unintelligible speech. This feature is also included in Cruz's (2012a) model, but absent in the LFC.

Schadech (2013) dealt with the production of word-initial /ɹ/ by Brazilians and the issues of intelligibility and comprehensibility. The stimuli consisted of tokens of BPSE productions of sentences that could make sense if they contained minimal pairs such as 'head' [hɛd] or 'red'

[13] Schadech and Silveira (2013) developed a study examining the comprehensibility of these phonemes by NSE.

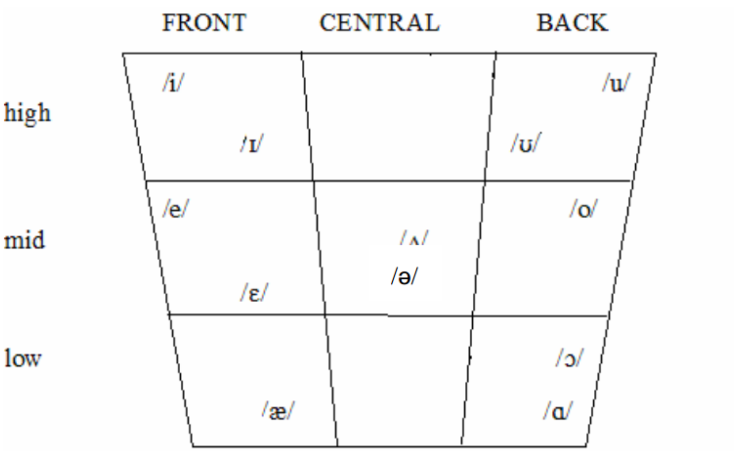
[ɹɛd]. The researcher had 73 listeners divided into three groups: (1) NSE; (2) advanced Brazilian speakers of English, mostly MA and PhD students; and, (3) students from the advanced level at *Cursos Extracurriculares*. Data collection occurred through a website where the participants were requested to transcribe the target words containing rhotics and a few distractors for the intelligibility assessment. Schadech (2013) found that the replacement of word-initial /ɹ/ for the fricative /h/ really hindered intelligibility. Similarly, Jenkins (2002) advocates in the LFC for the preservation of the rhotic ‘r’ rather than its non-rhotic varieties.

Having discussed the most relevant results of research on intelligibility in Brazil, I shall now address the BP and English vowel inventories.

2.4 Vowel inventories

Vowels can be characterized according to the position of the tongue, jaw, and lips in their production. They are usually described according to two main categories: one is related to the part of the tongue involved, and the other is related to the height of the tongue. Hence, traditionally, vowels are classified as regards frontness, middleness, and backness; and, according to (four) height dimensions: high, mid (which is divided into high-mid, and low-mid), and low (Yavas, 2011). Moreover, some vowels might be grouped as regards lip roundness. In American English (AE), and in Brazilian Portuguese (BP), all back vowels present the rounding feature.

The AE vowel system has ten monophthongs[14] (/i/, /ɪ/, /ɛ/, /æ/, /ə/, /ʌ/, /ɑ/, /ɔ/, /ʊ/, /u/), two homogeneous[15] diphthongs or semi-diphthongs (/eɪ/, /oʊ/), and three heterogeneous diphthongs (/aɪ/, /aʊ/, /ɔɪ/). Figure 1 displays the distribution of AE monophthongs and homogeneous diphthongs in the vocal tract (Rauber, 2006).



[14] In AE, all monophthongs and diphthongs are nasalized when they occur before a nasal consonant (Yavas, 2011).
[15] Roca, and Johnson (1999) as cited in Rauber (2006), explain that /eɪ/ and /oʊ/ are called homogeneous diphthongs because both phases of the diphthongs are close in articulatory position and share the lip gesture; as for /aɪ/, /aʊ/, /ɔɪ/, the two phases of the vowels are not close in articulatory position and do not share lip gesture, thus being called heterogeneous diphthongs.

Figure 1. Distribution of AE monophthongs and semi - diphthongs in the vocal tract[16]

The BP vowel system has seven oral monophthongs (/i/, /e/, /ɛ/, /a/, /u/, /o/, /ɔ/), five nasal monophthongs (/ĩ/, /ẽ/, /ã/, /ũ/, /õ/), and a number of ascending diphthongs (e.g., /eɪ/, /aʊ/) and descending diphthongs (e.g., /ɪa/, /ʊo/). Figure 2 displays BP oral monophthongs, whereas Figure 3 displays the nasal monophthongs (Marchal & Reis, 2011).

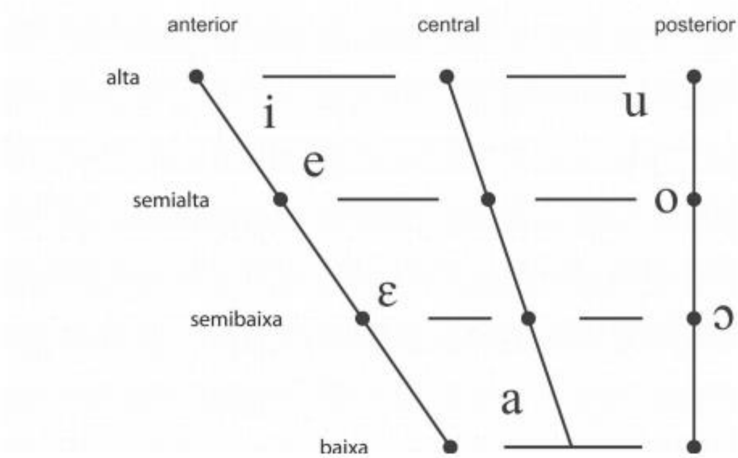


Figure 2. Distribution of BP oral monophthongs in the vocal tract[17]

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[16] Rauber, 2006, p. 23.

[17] Marchal & Reis, 2011, p. 165.

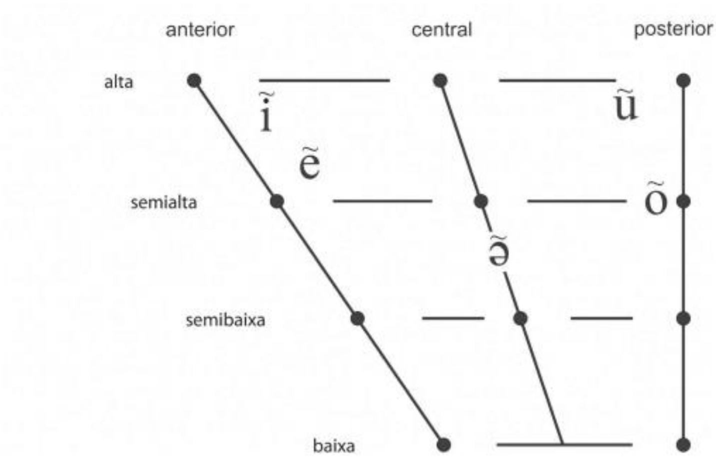

*Figure 3***.** Distribution of BP nasal monophthongs in the vocal tract[18]

Yavas (2011) posits that another binary grouping in AE vowels involves the distinction of tense and lax vowels. English has minimal pairs such as "seat" [si:t], and "sit" [sɪt], "fool" [ful], and "full" [fʊl], whose distinction is based on the tense/lax contrast. A tense vowel has a higher tongue position, greater duration than its "lax" counterpart, and it requires a greater muscular effort in production than the lax vowel (Yavas, 2011). In BP, tense/lax is not a distinctive feature used to characterize vowels (Cristófaro-Silva, 2012).

Moreover, English vowels are greatly influenced by surrounding consonants. Yavas (2011) remarks that this effect is much more

[18] Marchal & Reis, 2011, p. 169.

noticeable with liquids /ɹ/ and /l/ in AE. If the retroflex is in the same syllable as the vowel, the contrast among various vowels tends to disappear, e.g., in words such as ‘ear’ /ɪɹ/, ‘pier’ /pɪɹ/ for the contrast of /i/ and /ɪ/, attesting for what is commonly known as “r-coloring”. For the effect of the velar /l/ on vowels, Yavas (2011) demonstrates that postvocalic /l/ has a retracting effect on front vowels, resulting in more centralized vowels, in cases such as ‘meat’ and ‘meal’; and, ‘Mick’ and ‘milk’.

Thus, having explained that vowels are greatly influenced by the surrounding phonological environment, the data gathering instruments of this study present the vowels inserted in voiceless consonantal posterior contexts (/p/, /t/ and /k/). Section 3.2 (page 42) details the instruments developed for collecting data.

2.4.1 Characterizing vowels acoustically

Acoustically, vowels can be characterized according to their formant frequencies (F1, F2, and F3), and duration values. Formant frequencies relate to the vocal tract configuration. F1 relates to vowel height (how high or how low the tongue position is), whereas F2 usually relates to the resonance frequencies of vowel frontness and backness (i.e., if the tongue is pushed forward or backward) (Yavas, 2011). Ladefoged (2010) states that "the acoustic vowel space can be considered to be an area bounded by the possible ranges for the frequencies of the first two formants" (2010, p. 39). F3 relates to lip rounding, and thus is not investigated in this study, as this feature is not relevant to describe high front vowels.

In regard to duration, Ladefoged (2010) posits that, in English, length is not a distinctive feature used to distinguish vowels or consonants. However, it is an important cue to the devoicing in the final consonant pairs of words, such as in "*beat"* and "*bead"*, for vowels are shorter before voiceless consonants. Similarly, Lisker (1999) argues that information about the place of articulation of a consonantal segment can be provided with the formant frequency modifications of the vowel that precedes this segment. Nonetheless, for some L2 speakers of English, vowel duration is indeed used to differentiate vowel contrasts, such as /i/-/ɪ/ (Bion, 2007; Escudero, 2002, 2006).

Having described how vowels can be characterized, I now present Flege's *Speech Learning Model*, which will be used to discuss the results regarding vowel production.

2.4.2 L2 speech acquisition: Flege's *Speech-learning model*

Research has attested the major influence of one's L1 when learning any other L2[19]. As regards L2 speech, Flege (1995) claims that the mechanisms

[19]See Chapters 4 and 5 in Gass and Selinker (2008) for a discussion.

and processes used in the acquisition of the L1 will be applied to the sounds of an L2 at any age. The author's *Speech learning model* (SLM) proposes that the mechanism of *equivalence classification* will cause similar L2 sounds to be merged with those of the L1, so that different acoustic realizations will be perceived as belonging to the same phonetic category. Thus, phonetic differences between the L1 and the L2, and even within the L2, are not to be discerned by the speaker, leading to inaccurate L2 production. As regards this process, Flege (1995) remarks:

> During L2 acquisition, speech perception becomes attuned to the contrastive phonic elements of the L1. Learners of an L2 may fail to discern the phonetic differences between pairs of sounds in the L2, or between L1 and L2 sounds, either because phonetically distinct sounds in the L2 are "assimilated" to a single category, because the L1 phonology filters out features (or properties) of L2 sounds that are important phonetically but not phonologically, or both (Flege, 1995, p. 238).

Flege (1995) asserts that L1 and L2 categories exist in a common phonological space. New categories for vowels will then be established according to the dispersion of an L2 vowel from an L1 vowel. Therefore, learners need to adjust their acoustic space to accommodate new phonetic categories. Additionally, Baptista (2006) observes that "[…] these categories need to be linked in some fashion in the long-term memory, so that the representation for each vowel can include its position relative to the other vowels of the L2 system" (p. 20), showing that L2 vowels are acquired as a whole, with the accommodation of new phonetic categories in the vocal tract in relation to previously established categories.

Flege's SLM accounts for the fact that, in the present study, the investigated vowels were identified as possible realizations of an existing L1 vowel category in the participants' interphonology[20]. In order to better understand how these vowels are produced by the Brazilian speakers, I shall now review some studies which dealt with acquisition, perception and production of English vowels by BPSE.

2.4.3 Vowel studies in Brazil: acquisition, perception and production

From the many studies carried out so far dealing with vowel acquisition, perception, and production by Brazilians (Baptista, 2006; Rauber et al., 2005; Bion et al., 2006; Rauber, 2006; Nobre-Oliveira, 2007), I shall report findings of two of them (Baptista, 2006; Rauber, 2006), given their relevance to the present study.

Baptista (2006) developed a longitudinal study which investigated the acquisition of the English language vowel system by eleven native Brazilian-Portuguese speakers. Participants were five men and six women, who were residing in Los Angeles at the time the study was carried out, and, according to the researcher, "they had had varying

[20] See Selinker (1972) for a discussion on interlanguage.

amounts of English instruction in Brazil, but none […] was able to utter complete sentences in English without considerable hesitation, frequent pauses and backtracking" (p. 22).

Over a period ranging from four to eight months, participants were asked to read and retell a story in English which had many of the words used in the production test. The researcher, then, evaluated the participants' communicative competence level according to the level at which they were able to retell the story in the first session. Also, participants were recorded reading forty-two monosyllabic English words containing the seven vowels /i/, /ɪ/, /ei/, /ɛ/, /æ/, /ɑ/, and, /ʌ/ along with 13 distractors.

In regard to the pair of high front vowels, Baptista (2006) states that nine of the 11 participants failed to acquire the distinction between them, as "the emergence of an /ɪ/ appeared to have been literally blocked by the proximity of the inappropriately high IL /eɪ/ (modeled after Portuguese /e/) to the IL /ɪ/" (p. 26). Additionally, the two participants who acquired the /ɪ/ during the study "lowered their IL /eɪ/ at approximately the same time as they gradually lowered and separated /ɪ/ from /i/" (p. 27), attesting that one's L2 phonology categories need to be adjusted so that new categories can be developed.

As respects vowel acquisition, Baptista (2006) discusses that research examining the acquisition of L2 vowels should take into account the L2 vowel inventory as a whole (or large portions of the L2 vowel inventory), not only sounds in isolation, as learners do not acquire one vowel at a time, but rather build a whole system of interlanguage vowels simultaneously.

Rauber (2006) investigated the perception and production of three American English (AE) vowel pairs, /i/-/ɪ/, /ɛ/-/æ/, and /u/-/ʊ/, since they tend to be mispronounced and misperceived. Eighteen highly proficient Brazilian speakers of English took part in her study, from which 14 were M.A. and doctoral students from the Graduate Program in English (PGI) of the *Universidade Federal de Santa Catarina*. The research corpus consisted of sixty-six words, six for each of the eleven AE vowels, comprising the following six phonological structures: bVt pVt sVt tVt tVk kVp. They were produced by three different groups of speakers: AE monolinguals, BP monolinguals and Brazilian EFL speakers. The perception test is explained by the author as "a forced-choice labeling test which consisted of the participants' listening to one synthetic vowel and clicking on the label which most resembled the vowel heard" (2006, p. 90).

Rauber (2006) measured the Euclidian distance of vowels produced by AE monolingual speakers, and the Euclidian distance of vowels produced by L2 speakers, the degree of similarity between the Euclidian distance of both groups of participants, vowel duration, and amount of formant overlapping for each vowel category. When it comes to perception, the scholar measured the same categories explained above, plus the identification of vowels with different duration values (100ms, and 200ms). Given the complexity of her dissertation, two tables with all data summarized are presented, and some results concerning vowel production and perception reported below.

Table 1 summarizes the findings of Rauber's study for both the production and perception tests for the female and male participants. Table 1 contains information regarding the distance between the two vowels (Euclidean distance), the percentage[21] of similarity between the Euclidean distances obtained for the AE monolinguals and the L2 speakers, the duration of each vowel for the AE monolinguals and the L2 speakers, and the percentage of overlap between the F1 and the F2 values for each group of informants.

Table 1

Rauber's (2006) production test results for female and male participants

	Females	Males
Euclidean Distance (AE mon.)	678 Hz	440 Hz
Euclidean Distance	184 Hz	262 Hz

[21] This percentage was obtained by subtracting the L2 speakers' ED from the AE monolinguals ED, and multiplying the result times 100.

(L2 speakers)		
Similarity (%)[a]	27.1	59.5%
Duration (AE mon.)	/i/: 130	/i/: 140
	/ɪ/: 103	/ɪ/: 118
Duration (L2 speakers)	/i/: 129	/i/: 126
	/ɪ/: 123	/ɪ/: 102
Overlap (AE)	F1: 0%	F1: 0%
	F2: 0%	F2: 0%
Overlap (L2)	F1: 42%	F1: 0%
	F2: 37%	F2: 22%

Regarding the production test results, we can see that the Euclidean distances of both male and female AE speakers are much larger than the distances observed for the L2 learners. Nonetheless, we can see that the L2 learners are producing a distinction between the two high front vowels, despite not reaching the values obtained by the AE speakers. The results in Table 1 also clearly show that the AE speakers present longer duration for the tense vowel than for the lax vowel. Yet, for the L2 female speakers, the two vowels have similar duration (both pretty close to the duration of the tense vowels produced by female English monolinguals), and, for the male speakers, the results are similar to those obtained by the male English monolinguals. Note, also, that there is no overlapping between F1 and F2 values for the English monolinguals, which indicates that these vowels belong to separate categories in the American informants' vowel inventory. However, considerable overlapping is observed for the BP female speakers for both F1 and F2 values and for the BP males' F2 values. Clearly, the female BP speakers showed greater difficulty to distinguish between the two vowels.

Turning to the perception test results, Rauber found that both female and male L2 speakers obtained near native-like performance, thus showing that they tend to distinguish between the two high front vowels at the perception level. Apparently, the L2 leaners use both acoustic cues (F1, F2 values) and duration to make this distinction in terms of perception, but the good performance at the perception level does not carry over to the production level, especially for the BP females.

In general lines, Baptista (2006), by dealing with vowel acquisition, shows that the formation of new interlanguage categories can be delayed due to the influence of one's L1, whereas Rauber (2006), as regards vowel perception and production, attests that L2 speakers tend to accurately perceive L2 vowels, and yet are not as successful at distinguishing them at the production level. In sum, both studies show that English high front vowels pose a challenge to Brazilians.

2.4.4 The role of duration in discriminating L2 vowels

Research has suggested the importance of L2 listeners' reliance on duration cues to discriminate the high front vowel pair. Escudero (2002; 2006) has posited that L2 listeners are likely to rely on duration rather than on spectral quality (at least, for Spanish speakers of English) to distinguish between English front vowels. Interestingly, Escudero and Boersma (2004) have discussed that it is easier for L2 listeners to create a new vowel category based on a dimension that is not used in the L1, such as duration, than to accommodate new categories within the L1 inventory relying on spectral differences.

Other scholars have shed light on duration as a cue to distinguish between L2 vowels. Regarding the high front vowel pair, Bion (2007) suggests that Dutch speakers of English use duration as a parameter to differentiate these vowels. Also, Russian speakers of English (Kondaurova & Francis; 2008), Brazilian-Portuguese speakers of English (Rauber, 2006), and Catalan speakers of English (Kivisto de Souza & Mora, 2012) relied on temporal cues to discriminate the high front vowel pair.

The first experiment developed for the present study seeks to test effects of vowel frequencies (F1) over intelligibility. Duration data is reported along with the other acoustic dimensions in the method chapter, and its importance is addressed in Chapter 4. Having acknowledged the importance of duration to discriminate L2 vowels, I shall now take up on the relationship of intelligibility and perception.

2.4.5 The relationship between intelligibility and perception

To date, the great majority of findings garnered on vowel recognition come from perception studies, given the still little amount of research on intelligibility carried out in Brazil. Intelligibility and perception are different dimensions in the L2 speech research, and involve quite different methodological issues. Nonetheless, the perceptual ability of the listener is at play when identifying L2 vowels at an intelligibility task, which means that both intelligibility and perception are intertwined. Yet, research has not always succeeded in making it clear whether the two constructs differ from one another, and many linguistic features that may influence intelligibility have not been examined in detail.

The specificities of each of these two constructs should be crystal-clear when it comes to research methodology. As research has not paid attention to more refined approaches on intelligibility, research findings on intelligibility have been mistakenly explained on the base of "perception(s)" of listeners, when actually intelligibility was measured on the base of listeners' "impressions", "judgments" or performance on transcription tasks[22]. Thus, at least in speech research, "perception" and "impressions" or "judgments" shall not be used interchangeably. Furthermore, acoustic phonetic research has also used the term

[22] One of the examiners in the evaluation committee questioned how perception differs from vowel-level intelligibility, which is investigated in this study. I believe one of the aspects that can be raised in an attempt to answer that question is that overall research designs used in perception studies favor a cognitive approach, whereas investigations on intelligibility take into account many other variables with a different research design, as discussed in the present section.

intelligibility (e.g., Flege, 1992; Reis & Kluge, 2008) when reporting data collected with identification and discrimination tasks of perception studies. In this case, the authors are focusing on auditory perception, and the use of the word 'intelligibility' can be misleading.

As regards the variables related to each construct, intelligibility in the SLA field may involve auditory perception and also incorporate other factors, such as the cotext[23], lexical frequency, speech production and its acoustic characteristics, and learners' individual differences (e.g., listeners' familiarity with one's accent, listeners' use of language, listeners' proficiency, listeners' willingness etc.). Moreover, Munro (2011) states that intelligibility is "a well-established construct with a firm foundation in empirical and pedagogical traditions" (p. 8). Research focusing on intelligibility should be concerned with pronunciation aspects that influence communication in order to inform L2 pedagogy, as Munro (2011) discusses that intelligibility "[…] is the single most important aspect of communication. If there is no intelligibility, communication has failed" (p. 13).

Research on intelligibility takes up a social role (e.g., by considering speakers' and listeners' backgrounds, and the role of language use in a broader context), in order to shed light on the field of Applied Linguistics to come up with pedagogical implications. On the other hand, perception studies bear on a

[23] Catford (1965) defines "cotext" as the "items in the text that accompany the item under discussion" (p. 31).

cognitive approach and are generally more focused on linguistic variables, being concerned with drawing conclusions about L2 acquisition/phonology.

If available definitions for these constructs are taken into account, more observations on their differences can be drawn. Crystal (2008) defines perception as "[…] the process of receiving and decoding spoken, written or signed input. The underlying process is one of matching a set of cues to a stored representation" (p. 356). Thus, as regards perception, language is decoded in favor of a stored representation, which directly leads to the notion of phonology. Crystal (2008) also mentions that perception is usually related to production, so that it is possible to observe whether learners have already stored an underlying representation for a certain sound that they produce (which automatically takes on the relationship of phonetics and phonology as well). As previously demonstrated, Derwing and Munro (2008) define intelligibility as "the degree of a listener's actual comprehension of an utterance" (p. 479). Hence, these scholars show that the focus of research on intelligibility is broader and relies on the comprehension of a certain utterance, which presents varied phonological features. By focusing on the understanding of utterances, the agenda of research on intelligibility can be broader given its focus on (L2) communication. Also, when focusing on intelligibility at different levels, research can demonstrate more accurately the phonological traits that influence communication mostly.

Amano-Kusumoto and Hosom (2011) advocate that research needs to bring to light findings that elucidate how acoustic features can have an influence on speech intelligibility. The scholars elucidate that "phoneme intelligibility does impact word intelligibility" (p. 02). Thus, speech research shall have as its foci different levels (such as vowel level, and word level) in order to make available refined findings of phonetic nature, tested under more controlled circumstances, to better inform the field.

Moreover, the role of the cotext used in intelligibility assessment allows the listener to draw on different kinds of knowledge (e.g., syntactic and semantic clues are offered to the listener within the cotext), and "the availability of semantic cues, which are present in meaningful sentences, is an important factor that influences speech intelligibility" (Amano-Kusumoto & Hosom, 2011, p. 03), specially for the compensation of unclear speech. Such variable appears to be of sheer relevance when Derwing and Munro (2005) observe that when equal *cotextual* information is assumed, L2 practitioners shall wonder "why is one utterance understandable and another unclear?" (p. 386). The answer to the authors' wonder would pedagogically inform teachers on the aspects of pronunciation that should be covered in their lessons.

Auditory perception tasks make use of different types of tests (discrimination, identification, and goodness-of-fit tests, for instance), which present single isolated pieces of linguistic information to test for contrasts, where cotextual information is not of importance. Moreover, tasks on perception make use of the condition of repetition, whereas intelligibility is to be considered the first reaction of the listener (Cruz, 2004).

Even though intelligibility and perception data derive from a different nature of studies, research on L2 can profit from the variety of studies on these dimensions. The concern expressed in this section shall be taken into account so that studies can come up with clearer approaches and more refined research methods on intelligibility. Having briefly discussed the intelligibility and perception constructs, I shall discuss the variables investigated in this study.

2.5 Variables of the present study

In this section, I shall briefly describe some of the variables which have been attested by previous research to have influenced intelligibility, and discuss how some of them are dealt with.

Research on intelligibility has indicated a number of variables, related to speakers and listeners, which have an effect on measures of intelligibility. Some of the speaker-related measures are background noise (Cruz, 2004); speech rate (Munro & Derwing, 1998; 2001); and, the number of non-target productions (Munro & Derwing, 1995; Schadech, 2013). Moreover, some of the factors related to the listeners are familiarity with speakers' accent (Derwing & Munro, 1997; Cruz 2008; Cruz & Pereira 2006; Munro et al., 2006; Schadech, 2013), L1 background (Bent & Bradlow, 2003; Schadech, 2013), level of education (Smith and Rafiqzad, 1979; Munro et al., 2006), L2 proficiency (Bent & Bradlow, 2003; Hayes-Harb et al., 2008; van Wijngaarden et al., 2002); and, word familiarity (Bent & Bradlow, 2003; Bradlow & Pisoni, 1999).

Given the scope constraints of the present study, the variables investigated are all listener-related: length of residence in Brazil, henceforth LOR, as a measure of listeners' familiarity with the BPSE accent; listeners' L2 proficiency, and word familiarity.

Cruz (2008) showed that listeners who were not familiar with the speakers' accent had their comprehension of L2 speech negatively affected. The scholar reported that three different categories of speech errors affected intelligibility the most with unfamiliar listeners: word stress, orthography-motivated errors, and inaccurate consonant production. As for the familiar listeners, only one category considerably affected speech recognition: word stress. Thus, Cruz (2008) concluded that the L2 pronunciation was considered to be more intelligible to the listeners who were more familiar with the speakers' particular accent. However, findings on this variable still differ a lot as, for instance, Munro et al. (2006), and Schadech (2013) investigated the familiarity variable, but found no beneficial effect. Schadech (2013) did not find speech familiarity to have an effect on intelligibility to the reactions of listeners who were familiar with the speakers' accent (and even shared the same L1 background). Munro et al. (2006) showed only weak evidence that familiarity with one's accent leads to better understanding of L2 speech.

Bent and Bradlow (2003) investigated how L2 proficiency affected non-native talker intelligibility. Interestingly, these scholars found that all listeners considered the lower-proficiency non-native talkers less intelligible than either their high-proficiency counterparts or the native talker, showing that proficiency has a major effect on intelligibility. Van Wijngaarden et al. (2002) measured intelligibility of Dutch, English, and German sentences produced by native and non-native talkers of these three languages for trilingual listeners. The researchers found that when listening to English (their higher proficiency foreign language), the listeners found the native English talkers more intelligible than the non-native talkers, showing an intelligibility advantage over listeners and speakers who shared the same proficiency level.

By dealing with word familiarity, one study is of particular interest for the present research. Bent and Bradlow (2003) found that most of the words included in their experiment were assigned high levels of familiarity by the study participants. When testing for sentence in-noise perception, the researchers considered the word familiarity variable to be controlled because all listeners were sufficiently familiar with the words, and this variable was expected not to have an effect over intelligibility. In the present study, word familiarity will be measured as well, but the sentences will not be presented to the listeners in a noise condition. Furthermore, at least one word which is expected to be unfamiliar to L2 listeners (based on its frequency of use – see Table 3 in Chapter 3) is included to test its effect over intelligibility.

In this section, the listener-related variables which are investigated in this study were presented, namely, length of residence in Brazil, L2 proficiency, and word familiarity. Although previous research has shed light on other variables, this study is limited in its scope and cannot incorporate all of them.

Summary of the chapter

Overall, this chapter accounted for the recent developments in pronunciation research, which has shifted attention to aspects of L2 speech that have an effect over intelligibility. It was also seen that this study focuses on the production of English high front vowels, and on whether acoustic characteristics of these vowels have an impact on intelligibility. The notion of English as a Lingua Franca was discussed, along with definitions for intelligibility. The results of research on this dimension in Brazil were then reported. Furthermore, Brazilian Portuguese and English vowel inventories were briefly described, and the Speech Learning Model was explained due to the fact that this theoretical framework informs most of the empirical studies on vowel acquisition, perception and production with Brazilian participants. Then, some of the results regarding vowel acquisition, perception and production from studies with Brazilian participants were reported. Moreover, the relationship between intelligibility and perception was addressed, followed by a discussion on the variables investigated in the present study, namely, listeners' L2 proficiency, listeners' degree of familiarity with the tested words, and listeners' length of residence in Brazil. The next chapter draws on the method of the present study.

CHAPTER THREE

METHOD

The present study aims to investigate the intelligibility of utterances which include English high front vowels produced by Brazilian learners of English. The listeners are English users from different L1 backgrounds who completed an intelligibility test containing tokens produced by the Brazilian learners. The tokens were selected based on spectral proximity (F1 values) in an effort to understand if vowel frequencies affect cross-language intelligibility (see Section 3.3.3). As previous studies have shown that intelligibility can be affected by the listeners' proficiency level (Hayes-Harb *et al*., 2008; van Wijngaarden et al., 2002), a proficiency test (Oxford Placement test) was administered to the listeners so that a possible correlation between the listeners' performance on the proficiency test and their performance on the intelligibility test could be checked. Word familiarity is another variable which could hinder intelligibility (Bent & Bradlow, 2003; Bradlow & Pisoni, 1999), and the present study also investigates how familiar listeners are with the target words included in the intelligibility test (see Section 3.4.5), and whether the degree of word familiarity correlates with their performance on the intelligibility test. Finally, research on intelligibility has turned attention to how length of residence (LOR) indicates how listeners are familiar with one's accented-English (Cruz, 2004; Cruz & Pereira, 2006; Munro, *et al.,* 2006; Schadech, 2013). In the present study, listeners' LOR will be correlated to their scores on the intelligibility test in an attempt to identify a possible relationship between these variables.

Information on all research instruments and on participants is provided below, beginning with speakers' profiles and procedures to collect vowel production data, followed by listeners' profiles, the intelligibility test design, and procedures for data collection and analysis regarding intelligibility. Last, the research questions and hypotheses that will guide this study are presented, as well as the procedures to conduct the statistical analyses.

Before moving to the next section, it is important to explain that the acoustic data results are presented and discussed in this chapter as they were used to characterize the high front vowel categories in the speakers' interlanguage, and principally to help select the tokens used in the intelligibility test.

3.1 Speakers

Vowel production participants all volunteered. They were native speakers of Brazilian Portuguese (BP), all of whom were level-one students of English from two different groups at *Cursos Extracurriculares* at the time vowel data were collected. These participants were recruited not only because they were readily available for participation, but also because it would be possible to deal with vowel intelligibility and how these vowel categories were organized in the participants' interlanguage. Moreover, this choice takes into account the need for studies that examine L2 speech at the beginning and intermediate stages of acquisition (Zampini, 2008).

Participants went to the language lab individually to record a sentence-reading test after answering a questionnaire in class. Reading-aloud data from 20 participants, 13 women and 7 men, were recorded. They had been taking the English course for approximately four months, and had received absolutely no focused instruction on vowels by the time data collection occurred. The participants were receiving 3 hours per week of classroom instruction. The women's ages ranged from 18 to 46 (*M*: 24 years), and the men's ages ranged from 18 to 25 (*M*: 20 years). Moreover, baseline data were obtained from a native speaker of English, a 20-year-old male from Albany (NY). He volunteered to take part in the study. These native data were used to assess listeners' reliability (see Section 3.3.4).

A questionnaire[24] was given to speakers so that background information could be gathered. Based on Silveira (2004), and on Ruhmke-Ramos (2009), it elicited personal information, as well as information about participants' knowledge of foreign languages, and exposure to English (see Appendix C).

Concerning information about foreign languages knowledge, one participant acknowledged having prior knowledge of French, and two

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[24] Along with the questionnaire, participants were given a consent form as well. It is in accordance with *Resolução 196/96,* and it was reviewed and approved by UFSC research Ethics board under the register 242.979.

participants reported having prior knowledge of Spanish. Exposure to English in an English-speaking country was reported by two participants who responded that they had been abroad for a short period of time (from 12 to 15 days). Still, most students (17) reported that they had studied English during primary or secondary school in Brazil, and that nowadays they usually have contact with songs and films in English. Appendix A provides a more detailed description of each participant, including information about age, sex, occupation, and time spent in English-speaking countries.

Having pointed out the most relevant information about the participants who recorded the sentence-reading test, I now will explain how the corpus containing the target vowels was built (Sections 3.2, and 3.3), and how the tokens from this corpus were selected to design the intelligibility test (Section 3.4.4).

3.2 Sentence-reading test: gathering vowel tokens

Vowel data were supplied through a sentence-reading test. The speakers were required to read aloud sentences containing words with the target English vowels [i] and [ɪ], along with distractors. Schadech (2013) states that reading-aloud tasks have several limitations, but they also give the researcher the advantage of providing control over the studied phonemic categories and facilitate control over the phonological context in which these occur[25]. In

[25] "In addition, in extemporaneous speech some speakers might avoid producing certain sounds they have difficulty with, and thus leave the researcher without the speech samples s/he needs in order to investigate certain pronunciation features" (Schadech, 2013, p. 27).

addition, the instruments to gather data from speakers were piloted with 12 participants in encounters that occurred in three different sections. They reported that the instruments were objective and clear. Thus, no changes were made.

The target vowels were inserted in consonant-vowel-consonant (CVC) monosyllabic words which comprise the following phonological structures: bVt, kVk, pVk, pVt, sVt. Table 2 demonstrates the controlled phonological environment along with the tested words.

Table 2

Tested words within the controlled phonological environment

Phonological context	[i]	[ɪ]
b_t	beat	bit
k_k	keak	kick
p_k	peak	pick
p_t	Pete	pit
s_t	seat	sit

The need for controlling the phonological context is explained by the fact that the sounds surrounding the vowels affect their quality, especially the sounds in coda position (Ladefoged, 2010; Yavas, 2011). For instance, vowels followed by voiced consonants (e.g., “tab”) are longer than when followed by voiceless consonants (“tap”). Also, voiceless consonantal contexts allow a more precise identification of the first and last constant periodic pulses of the vowel sound wave displayed in a software, so, it becomes easier to identify the whole vowel for the acoustic analysis (Rauber, 2006). Furthermore, all the target words were inserted at the end of the sentences so that there would be a pause after them, which also facilitates the identification of the segment for analysis.

The sentence-reading test contained sentences where the target words were included in different cotexts ("Do you always keak?", "Do not kick"). Both declarative and interrogative sentences were included in each set. As the pitch decreased at the end of some declarative sentences, some of the tokens in this type of sentence could not be used as the target words were unintentionally whispered by the speaker, which causes the segments to be devoiced. The same did not happen with the interrogative sentences. These differences regarding intonation in the sentences prepared for data collection were not foreseen at the time the sentence-reading test was prepared. Vowel plotting was later on carried out to check if there were important differences in vowel quality considering the different intonation patterns of the carrier sentences. As there was none, both declarative and interrogative sentences were kept in the data set.

The sentences (Appendix B) included the words 'beat', 'keak', 'peak', 'Pete', and 'seat', which contain the tense vowel - [i]; and 'bit', 'kick', 'pick', 'pit', and 'sit', which contain its lax counterpart - [ɪ]. Ten distractors containing the English low-front vowels ([e] and [ɛ]) were inserted in the test, but they were not analyzed. All minimal pairs from the sentence-reading test were placed in the same syntactic environment, so that this would not become an intervening variable in the assessment of intelligibility. Word frequency and typical collocations with these words were not controlled for when the sentences were created (see Appendix B for the full sets of sentences). Nonetheless, as word familiarity is investigated in this study, it is as well fitting to examine word frequency, as language users are more sensible to more frequent linguistic items (Beckner et al, 2009; Trofimovich et al, 2012). Thus, it is also possible to check if these two variables are correlated and if they affect intelligibility in a similar way.

In order to assess word frequency, the Corpus of Contemporary American English (COCA[26]), was used given the fact that this corpus assembles texts of a wide range of genres: spoken language, fiction, popular magazines, newspapers, and academic journals (Davies, 2009). Table 3 displays word frequency of the ten tested words from COCA[27], and present them in a rank of frequency (RoF), which was used for helping to establish the frequency of the words utilized in the study.

[26] "The Corpus of Contemporary American English (COCA) is the largest freely-available corpus of English, and the only large and balanced corpus of American English. The corpus was created by Mark Davies of Brigham Young University, and it is used by tens of thousands of users every month (linguists, teachers, translators, and other researchers) (Davies, 2008).
[27] http://corpus.byu.edu/coca/. Other studies on intelligibility which dealt with word frequency as checked on COCA: Becker (2013); Schadech (2013).

Table 3

Frequency of the tested words according to COCA

[i]	Frequency in COCA	RoF	[ɪ]	Frequency in COCA	RoF
beat	40572	4th	bit	83131	1st
keak	4	10th	kick	12050	7th
peak	12597	6th	pick	42739	3rd
Pete	11318	8th	pit	6782	9th
seat	35594	5th	sit	45762	2nd

To have vowel production elicited, speakers were taken to the language lab individually to meet with the researcher. At the lab, they received a hardcopy version of the sentence-reading test, but were not allowed to read or rehearse the sentences before reading them aloud for recording. All speakers were instructed to hold the microphone up close to their mouths (around 5 centimeters away), and were told to repeat the entire sentence in case anything interrupted the reading. All the production data were digitally recorded by using Praat version 5.3.32 (Boersma & Weenink, 2012), at a sampling frequency of 22050 Hz, and a dynamic, multilateral SM 58 Plus "Le som" microphone. The computer used was a Toshiba Satellite C655.

The next section explains how the acoustic analysis was conducted in order to select words containing tokens of the English front vowels produced by the BP speakers in order to design the intelligibility test.

3.3 Acoustic analysis procedures and vowel tokens selection

In order to select the tokens for the intelligibility test, the high front vowels of the words of the sentence-reading test underwent acoustic analysis regarding three dimensions: first formant (F1), second formant (F2), and duration. These three dimensions were selected because they are used to characterize acoustically how the investigated vowels are produced in the vocal tract.

To gather data regarding formant frequency values, and also duration of the studied vowels, I made use of a script, "*Gera tabelas*", which was developed by Fernando Pacheco at the *Laboratório de Circuitos e Processamento de Sinais* (LINSE) at *Universidade Federal de Santa Catarina*. This script is run on Praat and automatically produces a chart presenting all values for the vowel acoustic features, including F3 (acoustic dimension related to lip rounding), which was not used in this study because high front vowels do not present rounding features.

By generating an acoustic representation of a speech signal (Figure 4), Praat provides two different acoustic images: (1) the oscillogram, and (2) the spectrogram. The oscillogram represents the acoustic signal in a two-dimensional way, where the vertical axis regards amplitude, and the horizontal axis corresponds to its duration. On the other hand, "the spectrogram analyzes a speech wave into its frequency components and shows variation in the frequency components of a sound as a function of time" (Yavas, p.101, 2011). The spectrogram represents the acoustic signal in a three-dimensional way, where the frequency is the vertical axis, time is the horizontal axis, and intensity is determined by the sound wave darkening, as the darker it is, the stronger the signal.

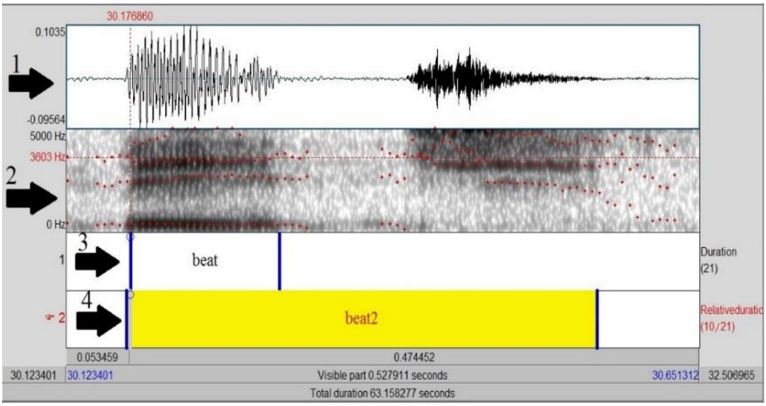

Figure 4. Acoustic representation of a speech signal on Praat ("*beat*", produced by a 32-year-old female, BP participant of the present study)

Number 3 in Figure 4 represents the tier where vowels were labeled, whereas number 4 is the tier where the whole word was labeled to extract word duration. Moreover, these labels are created in order to have vowel length measured, and also to have F1 and F2 values gathered from the labeled range in the digitalized sound wave. To do so, each vowel was manually labeled in the sound wave on Praat (Boersma & Weenink, 2012). I followed the analytical procedure presented by Rauber (2006), where either the beginning or the end of the selection in the sound wave must be close to a zero crossing, that is, when the wave crosses zero amplitude. The start and end points were considered to be the first and last periodic pulses on the waveform that have considerable amplitude and resemble the vowel period. Yet, to confirm if the arrow is selecting the beginning of the periodic pulses, the command "*ctrl 0*" on Praat takes the arrow to the starting point of the nearest periodic pulse. In the oscillogram (number 1 in Figure 4), the vowel starts at 30 seconds, as indicated when the first pulse appears.

To gather F1, F2, and duration values, the parameter is the reliable automatic analysis provided by the script run through Praat. Before running the script, each vowel was manually labeled in the digitized sound wave, where either the beginning or the end of the selection in the sound wave must be close to a zero crossing. Again, the start and end points were considered to be the first and last periodic pulses on the waveform that have considerable amplitude and resemble the vowel period (see Section 3.4.1).

Moreover, the script gathers data for formant frequencies from three different portions of the vowel. For analysis, data from the second portion is considered the most reliable, as data from the first and last portions are more influenced by the preceding and the following sounds in the context. Thus, steady-state portions from the center were used in the analysis (Baptista, 2006; Seara, 2013).

Having discussed the most relevant aspects regarding the acoustic features of vowels in the present study, I shall now explain the statistical procedures employed to observe whether the vowels produced by men and women have similar acoustic features.

3.3.1 Comparing female and male data

Previous studies have consistently analyzed vowel tokens separately (Bion et al., 2006; Nobre-Oliveira, 2007; Rauber, 2006; Rauber et al., 2005) due to the physiological differences that lead to different acoustic features in the vowels produced by speakers from different sexes. The present study relies on statistical procedures to decide whether the differences between men and women are considerable. Furthermore, both normalized and non-normalized versions of vowel plotting are demonstrated and discussed.

The statistical analysis reported below was guided by the hypothesis that there are significant differences between the means of the high front vowels produced by men and women. The first step was to create a spreadsheet in SPSS software[28] with data regarding F1, F2, and duration of each vowel token separated by sex. Descriptive statistics and normality tests (Larson-Hall, 2010) were run to check the data for normal distribution. The results indicated that the data were not normally distributed ($p < 0.05$, see Appendix J). Thus, non-parametric tests (Mann-Whitney U) were run to compare the F1, F2, and duration values for

[28]Statistical Package for Social Sciences (Version 16).

female and male speakers, which showed that the differences between the groups (men and women) were significant ($p = .000$).

Having established that the differences in vowel production between men and women are significant, and therefore data from the two groups should be analyzed separately, I shall now explore how vowel plotting was carried out.

3.3.2 Vowel plotting: comparing English high front vowels

After having gathered all rough acoustic vowel data by making use of scripts, the next step was to carry out vowel plotting. In order to do so, F1 and F2 values for vowels which were clearly mispronounced in the production reading tests (for example, when "ea" in "beat", was pronounced /ɛ/, resulting in [bɛt][29]) were excluded from the data spreadsheets. Two different methods of vowel plotting were carried out: normalized and non-normalized vowel plotting, as data presented in these two ways usually differ in terms of showing vowel distribution in the speakers' vocal tract.

To have non-normalized vowel data stratified, the procedures for building vowel graphs were conducted through the script "*Plotar vogais*", written by Bion (2006)[30]. To obtain vowel dispersion (vowel *loci*), the script used was

[29] F1 values for a vowel such as /ɛ/ are usually around 550 Hz, which are higher than F1 values for the high front vowel pair (Yavas, 2011). In the data spreadsheets, they are easily identifiable. However, the researcher also checked if the vowel was in fact mispronounced by conducting an auditory analysis.
[30] This script was modified by Andreia Rauber in 2010, and by Fernando Pacheco in 2012.

"*Plot from table*", also written by Bion (2006)[31]. Both scripts were run on Praat; the input for both of them were Excel data charts (in txt. extension) displaying the speakers, the high front vowel feature (tense or lax), and F1 and F2 values. The plotting with non-normalized data compared sex (female versus male production) in the sentence-reading test; and, native versus non-native production, which was not used in the present study. All English native vowel data were retrieved from Rauber (2006).

Additionally, normalizing vowel tokens is necessary to reduce the physiologic differences among men's and women's production, allowing the researcher to focus only on the linguistic differences. To have normalized[32] vowel data, the LOBANOV procedure was used. This is a vowel extrinsic normalization procedure which requires information distributed across more than one vowel of a talker. It takes formant frequencies as input and generates output in normalized versions of those formant frequencies (Adank, *et al*., 2004). Normalized data are analyzed acoustically in the present study, but were not taken into consideration for the intelligibility test preparation (see Section 3.3.3), as data from Rauber (2006) are represented in their non-normalized version, and the present study makes use of the English native speakers' F1 and F2 values from Rauber (2006) to compare with the values produced by the Brazilians who provided data used in the present study intelligibility test.

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[31] This script was modified by Fernando Pacheco in 2012.
[32]The normalization formula is Fn[V]N = (Fn[V] - MEANn)/Sn, where Fn[V]N is the normalized value for Fn[V] (this is the formant frequency of the vowel (V)); MEANn is the mean value for formant *n* of the speaker who supplied the token; and SN is the standard deviation for the formant *n*.

According to Adank, *et al* (2004), LOBANOV preserves phonemic variation best, reduces anatomical/physiological variation most effectively, whilst also preserves nearly all sociolinguistic variation in the acoustic measurements. This procedure is easily done through the website "Norm: vowel normalization suite 1.1"[33] (Thomas & Kendall, 2012). I hereby explain the steps taken to conduct this procedure.

To look at the distribution of vowels in the acoustic space, I assembled normalized data for participants' sex. The normalization was carried out twice, firstly for *individual vowels* in order to look at vowel dispersion, and secondly for *speaker means* to look at group differences. In order to have results plotted in Hz, the scale results processing was chosen, whereas plot standard deviation was chosen to be one. Moreover, F1 and F2 values of [ɑ] and [u] from Rauber's (2006) study were inserted along with F1 and F2 values of the high front vowels from the present study so that the graph resembles the vowel distribution in the vocal tract. Otherwise, if vowels from different heights and backness are not used, the normalization centralizes the vowels and F1 and F2 values are modified. The present study presents a total of 184 high front vowels tokens[34].

As previously mentioned, the present study investigates whether Brazilian learners of English, with an elementary proficiency level, produce a

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[33] http://ncslaap.lib.ncsu.edu/tools/norm/norm1.php

[34] In addition, other vowels can be used when performing normalization procedures, as normalization methods that use information across multiple vowels usually perform better. These methods preserve phonemic information, information on the talkers' regional background, and sociolinguistic information best. Moreover, by having F1 and F2 values of vowels such as /a/ and /u/ in the data set, the vowel chart gets easier to read.

distinction between /i/ and /ɪ/, or whether they tend to produce both vowels as being equivalent to the BP high front vowel /i/. Figures 5 and 6 were built using the BP speakers' data, and they display vowel dispersion for sex differences at the first set of sentences, in non-normalized and normalized versions.

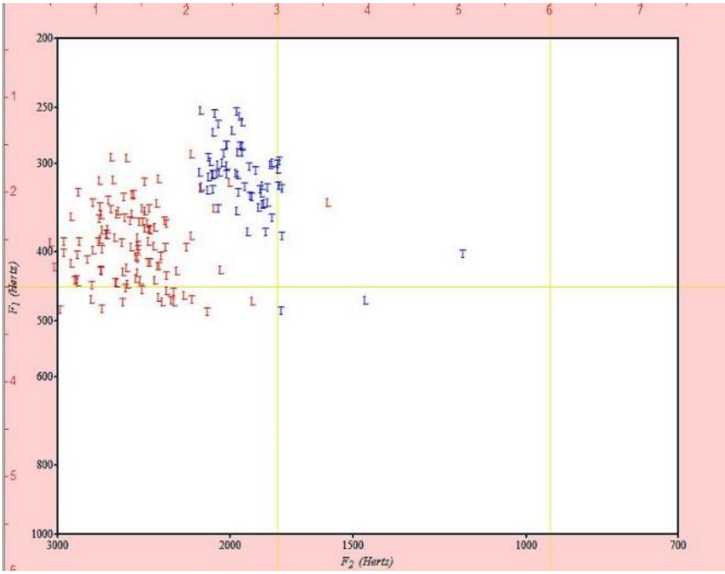

Figure 5. BP speakers' vowel dispersion in the acoustic space within non-normalized values, separated by sex. Women's production is displayed in red, and men's production in blue. The vowels are represented by their tense (T) and lax (L) distinction.

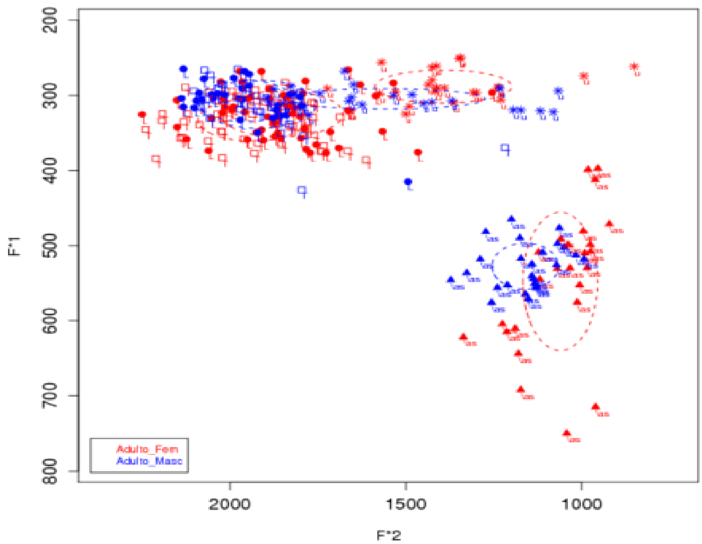

Figure 6. BP speakers' vowel dispersion in the acoustic space within normalized values, separated by sex. Women's production is displayed in red, whereas men's production is displayed in blue. The vowels are represented by their tense (T – squares) and lax (L – full circles) distinction. Data for [ɑ] and [u] are also displayed (see Section 2.4).

As can be seen in Figure 5, female token distribution is more disperse, presenting an F1 range which varies from 300 Hz to 500 Hz, indicating the variation of the constriction of the pharynx. F2 values are presented within a range from 2000 Hz to 3000 Hz, demonstrating how women's high front vowel production varies regarding vowel frontness. There appears to be a greater number of tokens concentrated in an area where F2 reaches 2500 Hz, showing a tendency on /i/-/ɪ/ to be produced both frontwards. Male F1 values vary from 250 Hz to 360 Hz, showing a tendency for male front vowels to be higher than female vowels. F2 is more compact than women's, ranging from 1800 Hz to 2100 Hz, and indicating a tendency on the tongue to move backwards.

As Figure 6 indicates, there is considerable variation in the normalized vowel plotting of the high front vowels[35]. Both men's and women's productions are asymmetric and disperse through the acoustic space. As regards female production, there is a bigger concentration of tokens in an area where F1 ranges from 300 Hz to 400 Hz, showing how BP learners vary on vowel height for the front vowel pair. F2 for female production appears to be concentrated mostly from 1800 Hz to 2200 Hz, giving evidence that these vowels also vary considerably regarding frontness and backness. F1 for male production ranges mostly on an area of 300 Hz, being lower and more fronted than female production. Male F2 goes from 1800 Hz to 2200 Hz, similarly to the results of female F2. Most importantly, Figure 6 shows that, if physiological differences are excluded, female and male speakers tend to produce the same vowels indistinctively.

Figures 7 and 8 were built using the BP speakers' data, and they display vowel dispersion for group means, in non-normalized and normalized versions.

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[35] As mentioned in section 2.4, the normalized plots also display information about [ɑ] and [u], taken from Rauber (2006), which were used so that the graph resembles the vowel distribution in the vocal tract.

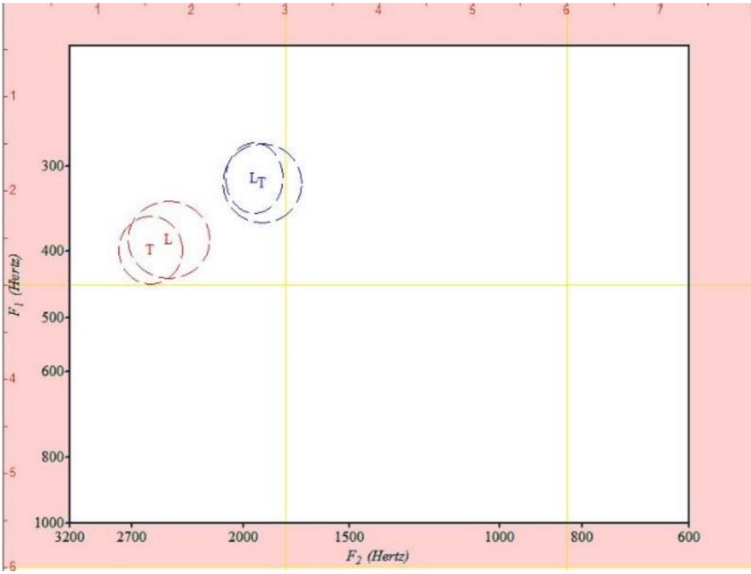

Figure 7. BP speakers' vowel means in the acoustic space within non-normalized values, separated by sex. Red dots represent female tokens, while the blue ones represent male tokens. The vowels are represented by their tense (T) and lax (L) distinction.

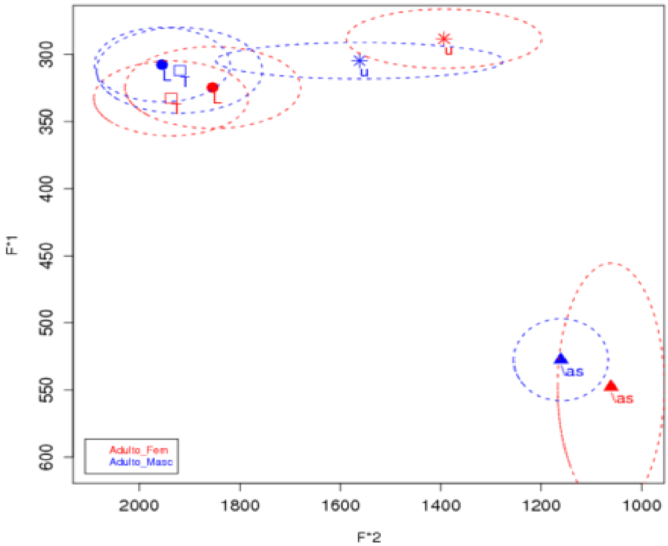

Figure 8. BP speakers' vowel means in the acoustic space within normalized values, separated by sex. Red dots represent female tokens, while the blue ones represent male tokens. The vowels are represented by their tense (T – squares) and lax (L – full circles) distinction. Note that tokens of [ɑ] and [u] (represented by triangles and asterisks, respectively) were included (see Section 2.4)

As can be seen in Figure 7, female tense and lax vowels are very close and more fronted than male. The female tense vowel was lowered, and the female lax vowel raised and moved back. Male lax vowel is slightly higher than its tense counterpart. However, they are quite close and appear to be produced with little distinction in the male vocal tract.

In Figure 8, male and female tokens are quite close. Men's production appears to be slightly higher than women's. Regarding frontness, there appears to be some variation, but the vowels are very close. Women's tense vowel is more fronted than its lax counterpart, whilst for men, the opposite is seen - the lax vowel is slightly more fronted than its tense counterpart.

Both non-normalized and normalized data sets show that high front vowels production is asymmetric. A great number of the lax vowel tokens range in an area of a higher F1 (300-400 Hz), showing that this vowel was raised; whilst with the tense vowel, the F1 values are concentrated in the same area, indicating that this vowel was lowered. Thus, both vowels overlap and are produced in the same fashion by the BP learners of English. F2 values for both vowels are very high, confirming that these vowels are produced with the enlarging of the back cavity and the body of the tongue raised frontwards.

Turning now to the duration data, duration means of the present study were compared (1) to the means of monolingual speakers of English (Rauber, 2006) and (2) to the means of BP /i/ produced by monolingual speakers of Brazilian-Portuguese (Rauber, 2006). Table 4 displays the duration values used for comparison from Rauber (2006), and Table 5 displays the duration values obtained in the present study.

Table 4

Duration values in milliseconds of monolingual speakers of English (Rauber, 2006) and monolingual speakers of Brazilian-Portuguese (Rauber, 2006)

	Monolingual English female		Monolingual English male		Monolingual BP /i/ female	Monolingual BP /i/ male
	/i/	/ɪ/	/i/	/ɪ/		
Dur. Mean	130	103	140	118	92	95
Dur. Median	125	105	134	115	94	95
Dur. SD	28	22	24	20	19	17

Table 5

Duration values in milliseconds of BP speakers of English from the present study

	BP speakers of English - female		BP speakers of English – male	
	/i/	/ɪ/	/i/	/ɪ/
Dur. Mean	98	82	96	92
Dur. Median	95	81	100	94
Dur. SD	39	28	26	24

Table 5 shows that the BP female and the male tense vowel had very similar duration means (98-ms, and 96-ms). As for the lax vowel, the BP female participants had the shortest vowel (82-ms), whereas the BP male participants had a mean similar to the one obtained for their tense vowel (92-ms).

The duration values of the present study also appear to differ from the native means obtained by Rauber (2006) displayed in Table 4. If compared, the lax vowel, as produced by the BP and the AE female participants, had the closest mean (BPSE: 82-ms – AE: 103-ms), and even so there was some difference. If different vowels are compared, the means for the L2 longest vowel [i], as produced by the BP informants (females = 98-ms and males = 96-ms) approach the means for the English monolingual shorter vowel [ɪ] (females = 103-ms and males = 118-ms), having the closest means in duration.

When the duration values for the two L2 vowels produced by the BP spearkers are compared to the duration values of the Brazilian-Portuguese /i/, it is clear that the means have very similar values. These results show that the English high front vowels were produced by the BP speakers with temporal cues similar to the BP /i/ category. For BP /i/, female and male participants had close means – 92-ms and 95-ms, respectively. These numbers approach the means obtained by the BPSE when producing the English high front vowel pair – for the tense vowel, 98-ms and 96-ms; as for the lax vowel, 82-ms and 92-ms. Thus the duration results, as well as the F1 and F2 values result indicate that at the initial stages of L2 acquisition, BP learners of English tend to produce the English high front vowels with the acoustic features of the L1 high front vowel.

Having presented the vowel analysis, I shall discuss now the acoustic criteria set in order to select tokens for the stimuli of the intelligibility test.

3.3.3 Selection of samples for the intelligibility test

This section presents the criteria used to select the samples for the intelligibility test. In an attempt to better understand the acoustic properties which may affect intelligibility, all stimuli were selected based on F1 criteria. Literature has shown that non-native listeners tend to rely on durational cues to discriminate L2 vowels. However, there has not been any intelligibility study to deal with acoustic properties of speech, such as vowel frequencies. The first frequency was chosen due to the fact that dispersion in the first frequency is more salient than in the second. Moreover, the standard deviation (SD) values utilized to selected the tokens from the first frequency would not be the same for the second. Thus, by deciding to test only F1, the F1 values of the vowels produced by the BP learners of English were compared to the mean F1 values of English native speakers reported by Rauber (2006). The acoustic criteria set to choose the samples was based on one SD either below the F1 mean, above the F1 mean, or close to the F1 mean for the high front vowels produced by monolingual American speakers of English who took part in Rauber's (2006) study. Table 6 displays the means and the standard deviations (SD) for the F1 used for comparison.

Table 6

F1, F2, and SD, means and medians from Rauber (2006)

	F1 mean	F1 median	F1 SD
/i/ - female	308	306	35
/i/ - male	280	276	22
/ɪ/ - female	501	518	55
/ɪ/ - male	412	423	43

Using the +/- 1 standard deviation criterion and observing the different values for female and male, 32 tokens produced by the BP speakers were selected to compose the intelligibility test. Five tokens were below 1 SD, other five were above 1 SD, five were close to the English native speakers' mean. In order to control for listener effect, I selected three sentences which were produced by a native speaker of English, and one sentence produced by a BP speaker was repeated. The other fifteen sentences, produced by BP speakers, were ten distractors with the low-mid ([ɛ] and [e]) vowel pair, five played twice. Thus, the intelligibility test contained a total of 35 tokens, embedded in 35 carrier sentences.

Table 7 displays the tokens selected for the intelligibility test based on the SD criterion.

Table 7

Tokens selected for the intelligibility test

Participant	Gender	F1 value for /ɪ/	Criteria	Target word
S01	Female	442	Below 01 SD	bit
S02	Female	419	Below 01 SD	pit
S05	Male	306	Below 01 SD	kick
S09	Male	343	Below 01 SD	pick
S11	Male	270	Below 01 SD	sit
Participant	**Gender**	**F1 value for /i/**	**Criteria**	**Target word**
S04	Female	468	Above 01 SD	peak
S07	Female	451	Above 01 SD	Pete
S09*	Male	380	Above 01 SD	beat
S12	Female	372	Above 01 SD	seat
S14	Female	414	Above 01 SD	keak
Participant	**Gender**	**F1 value**	**Criteria**	**Target word**
S02	Female	472	Close to the mean	pick
S09	Male	307	Close to the mean	keak
S11	Male	311	Close to the mean	seat
S11	Male	310	Close to the mean	peak
S14	Female	440	Close to the mean	bit

NS	Male	--	Native	kick
NS	Male	--	Native	sit
NS	Male	--	Native	beat

*Token repeated once

In addition to the acoustic criteria, sentences included in the intelligibility test were also inspected regarding other criteria. Samples with grammatical errors induced by the speakers' misreading were excluded because they could affect listeners' performance[36] (Derwing, 2008). Furthermore, following Cruz (2004), (1) the intelligibility test does not present any sequences of samples produced by the same speaker so that listeners do not become familiar with the speech of a particular talker, (2) there is no background noise in the recordings, and (3) only meaningful sentences were used.

The intelligibility test worksheet was handed to participants after they took the proficiency test (Section 3.4.1). The worksheet presented the 35 sentences without the final target words. Participants listened to one sentence at a time and were asked to write down, to the best of their knowledge, the word they heard. Except for the sentence which is repeated last in the test, none of the other sentences were played twice, as intelligibility is considered to be the first impression (Cruz, 2004, 2008; Cruz & Pereira, 2006).

[36] "[…] Ungrammatical and, thus, somewhat unpredictable structures, led to harsher judgments of pronunciation" (Derwing, 2008, p. 355).

3.4 Intelligibility assessment participants

All 32 listeners volunteered. Thirty-one were monolingual speakers of ten different L1s, and one listener was a Dutch-French bilingual. Figure 9 displays listeners' L1 background.

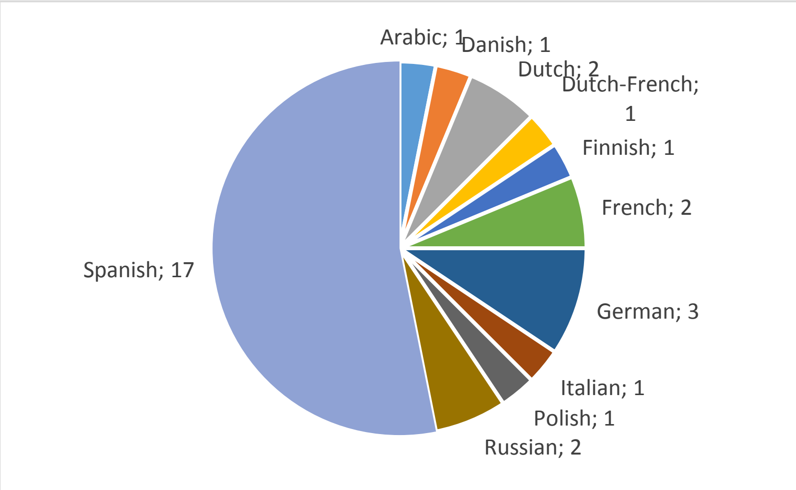

Figure 9. Listeners' L1s

All listeners were recruited through informal advertising and social networking. The experimenter investigated if participants were able to reasonably communicate in English through an informal face-to-face interview, as this was a requirement to take part in the study. They received a questionnaire[37] so that

[37] Along with the questionnaire, participants were given a consent form as well. It is in accordance with *Resolução 196/96*, and it was revised and approved by UFSC research Ethics board under the register 242.979.

background information was gathered. It elicited personal information, as well as information about participants' knowledge of foreign languages, exposure to English, length of residence in Brazil, and use of language in Brazil (see Appendix E).

Listeners were 18 men and 14 women, whose length of residence in Brazil ranged from 2 weeks to 80 months (*M*: 4.5 months). Women's ages ranged from 18 to 29 (*M*: 24.5), whereas men's ages ranged from 19 to 50 (*M*: 25.5). The great majority of participants reported speaking several L2s (usually, from two to five) - only one participant reported speaking only one L2.

Concerning the information reported by the listeners in the questionnaire, 21 participants had visited a number of English-speaking places (Canada, England, Hong Kong, India, Ireland, Jamaica, New Zealand, the USA, Netherlands, Scotland, Singapore), and 4 reported that they had lived in English-speaking places (from 1 to 20 years, in places such as Canada, Hong Kong, Ireland, and the USA). Most participants acknowledged learning English at schooling environments (such as language schools, and at the university), and by going to places where English is widely spoken and used. Moreover, when it comes to domain-based use of English, all of them reported that they used to speak English with Brazilians in personal affairs, and for some of them, English was the sole language used for communication in Brazil. Yet, listeners informed that the major difficulty is to understand Brazilians' pronunciation when interacting with them in English, and Brazilians' lack of vocabulary.

Having pointed out the most relevant information about the listeners, I shall now explain the instruments they were given, beginning with the Oxford Placement test (Section 3.4.2), followed by the Intelligibility test (Section 3.4.3), and the word-familiarity test (Section 3.4.5).

3.4.1 The Oxford Placement Test

Listeners were given a placement test to check for a possible relationship between proficiency level and their performance on the intelligibility test. The proficiency test chosen was the pen and paper version of the Oxford Placement Test (Allan, 2004), henceforth OPT, as it has been used in previous research (e.g., Alves, 2009; Perozzo, 2013), and it is widely-used by language schools for being easy and quick to administer.

The pen and paper OPT assesses three different skills: Reading, Vocabulary, and Grammar. All the test questions are in multiple-choice format. It consists of two parts: The first part presents reading tasks, including simple texts with graphic support, whereas the second part, which assesses core competence, presents test-takers with multiple-choice cloze and discrete multiple-choice questions (Allan, 2004). Listening and speaking skills are not assessed by the OPT, but listeners' speaking skills were assessed through the informal interview which took place when they encountered the experimenter (see Section 3.4). Moreover, listeners were required to rate their English listening and speaking skills in the questionnaire.

Following the Common European Framework of Reference for Languages, the OPT assigns six proficiency levels: A1: *Breakthrough*; A2: *Elementary*; B1: *Lower intermediate*; B2: *Upper Intermediate*; C1: *Lower advanced*; C2: *Upper advanced*. Appendix L displays the score ranges that test takers should obtain to be placed at each level.

The results of the OPT revealed that listeners' proficiency levels were elementary (05), lower-intermediate (11), upper-intermediate (07), lower-advanced (05), and upper-advanced (04). The next section presents all relevant information on the instruments used to gather intelligibility data from the listeners.

3.4.2 Intelligibility test

The intelligibility test includes utterances produced by the BP speakers who completed the sentence-reading test (see Section 3.3.3). The sentences were all mixed with distractor-sentences (e.g. '"I love you', she said"; "Do you like your pet?") not to bias the listeners into predicting the target sounds. As explained in Section 3.3.4, acoustic criteria were used to select the tokens to be included in the intelligibility test. Thus, only sentences containing target words whose [i] and [ɪ] sounds displayed specific F1 values were selected. As a result, the intelligibility test contains tokens of [i] and [ɪ] with F1 values that are typical of English native speakers' productions, as well as values that deviate from the mean, and thus, which are typical of BP speakers of English interphonology. In order to inspect listeners' possible bias toward the speakers, sentences produced by a native speaker of English were also included in the test. Table 3 (Section 3.3.3) shows further details about the sentences that comprise the intelligibility test.

The intelligibility test sheet was developed so that listeners could transcribe Brazilian speakers' tokens. Following a common procedure in studies assessing intelligibility (Munro, 2008), listeners were asked to orthographically transcribe the missing words in the sentences included in the intelligibility test, after listening to them individually (Appendix G). The experimenter piloted this instrument to observe listeners' performance when orthographically transcribing the entire sentences and when transcribing only the missing words in final position to decide which procedure should be followed. The participants were a university professor, a graduate student, and two undergraduate students who volunteered to help with the pilot study. After giving the test, the experimenter observed that there were no considerable differences regarding the target-word transcriptions when full sentences or only final words were transcribed. Thus, in order to avoid listeners to misinterpret the stimuli, which would lead them to create new sentences and put at risk the use of the tested target words, the researcher chose to assess intelligibility by asking the listeners to transcribe the final word. Moreover, it is worthwhile to posit that these final words were inserted in meaningful cotexts.

Sentences 1 and 2 illustrate how listeners were presented with the intelligibility test.

You are about to listen to 35 sentences. After listening to each sentence, write down to the best of your ability what you understand.

1. Can you wait a _________

2. The doctor _________

After having explained the design of the intelligibility test, I turn now the discussion to how word familiarity, one of the variables that could influence intelligibility, is measured in this study.

3.4.3 Word-familiarity test

Based on Bent and Bradlow (2003), a word-familiarity test was developed to check how familiar listeners were with the test words heard in the intelligibility test. Thus, I shall be able to check whether being familiar or not with the vocabulary is a variable which plays a role in intelligibility assessment in the present study.

I developed a Likert rating scale to measure listeners' familiarity with the intelligibility test words, mostly by adapting a scale designed by Bent and Bradlow (2003). The scale presents 4 levels, ranging from 0 to 3, where "0" = "I do not know this word; "1" = I think I have seen this word before", "2" = I recognize this word as an English word, but I do not know its meaning"; and, "3" = "I know this word".

Listeners received a worksheet where the familiarity scale was inserted on the top of the page, and they were required to rate each word containing the target sounds presented in the intelligibility test. Below is an example of the word familiarity test with the target word 'bit'.

Bit

0	1	2	3

All 20 words used in the intelligibility test stimuli were rated, but I analyzed only the 10 words containing the high front vowels. The data gathered by the word-familiarity test were later correlated to listeners' performance on the intelligibility test to check if listeners were able to transcribe the target words and how accurate their transcriptions were, given the level of familiarity they assigned to the tested words.

Having described the research instruments used for data collection, the following sections present the procedures to collect data from the listeners, and how the data were analyzed.

3.5 Intelligibility data collection and analysis

All listeners met the researcher at the Language Lab at *Centro de Comunicação e Expressão*. Individually, they were given (1) the consent form,

(2) the intelligibility test, (3), the proficiency test, (4) the word-familiarity test, and last (5) the questionnaire. All instruments were administered in a row.

The intelligibility test was administered first. Next, the proficiency test was given, so that listeners would not be biased when filling in the word-familiarity test, which was administered right after. Moreover, the questionnaire was given last as it sought explicit information on how participants dealt with Brazilian-accented-English, which would certainly influence their performance towards the speakers' identity.

In each listening section, the researcher controlled the presentation of the stimuli by pressing a pause button at the end of each utterance so that a new stimulus was not presented until the participant had finished transcribing the previous one. All the stimuli were played on BS Player, using a Toshiba Satellite C655 computer, along with a Microsoft headset LifeChat LX-3000. Each encounter lasted around one hour[38].

As regards data analysis, based on Bradlow and Pisoni (1999), a word transcribed by the listeners is to be counted as correct if all the letters are present and in the correct order. Yet, to allow for orthographic influence, if diphthongs such as "ee" appear to be used in order to replace "ea" (in 'beat', for instance), for having the same vowel sound (and, thus, creating a homophone), this transcription is also to be considered correct. Notwithstanding, these criteria

[38] It varied, though. Some listeners took more time to process the speech they had just listened to. I reckon speech processing time also might reveal something about L2 speech recognition. However, this is a remaining gap in the present study.

allow for intelligibility to be looked at within different levels: (1) vowel-level intelligibility, where vowel recognition is checked; and, (2) word-level intelligibility, where vowel recognition is to be looked at, mostly due to the acoustic-phonetic dimensions used for segment recognition (Section 3.3.3).

Furthermore, to check for listener consistency (intra-listener reliability), two sentences were repeated in the intelligibility test. The orthographic transcriptions of the target words in these sentences will be compared in order to examine the extent to which listeners transcribed them the same way in times 1 and 2. I shall also examine the way the listeners transcribed the English native speakers' tokens to observe possible bias toward the BP speakers' data.

As regards the word-familiarity data, the familiarity ratings assigned by the listeners will be computed separately according to each word on SPSS, so that descriptive statistics can be run. The values obtained with this test will also be correlated on SPSS to data regarding word frequency. Both word familiarity data and word frequency data will be correlated with the intelligibility test results. Finally, data regarding listeners' length of residence in Brazil will be correlated with the intelligibility test results as well.

Having explained each step taken to conduct vowel collection, and showing how these data will be analyzed, I shall now demonstrate the Research Questions (RQ) and Hypotheses (H) that guide the present study, along with the statistical procedures employed.

3.6 Research questions, Hypotheses, and Statistical analysis

In order to investigate the intelligibility of English high front vowels produced by BP speakers of English, this study aims to answer five research questions. Each RQ will be stated and accompanied by hypotheses and theoretical background supporting these hypotheses.

RQ1: Which of the high front vowels produced by the Brazilian speakers causes more intelligibility problems at vowel level and at word level?

H1: Both vowels will cause intelligibility problems at both levels.

As regards the general results of the acoustic analysis in Section 3.3.2, BPSE were not able to produce the high front vowels distinctively. Thus, it is expected that NNL will not be able to discriminate the vowels accurately in the intelligibility test, at vowel and word level.

To answer RQ1, I looked at the transcriptions from the intelligibility test, and compared these transcriptions to the target words which were intended by the speakers when recording the sentence-reading test. The data were separated according to vowel type, and vowel and word level.

RQ2: How do the F1 values of the high front vowels produced by the Brazilian speakers affect intelligibility?

H2: High front vowels with F1 values which are further from the mean of the native speakers, either one standard deviation below or above, will affect intelligibility the most.

Tokens containing high front vowels with F1 values one SD below or above the mean, as well as tokens whose F1 values approached the means reported by native speakers of English were included in the intelligibility test. The listeners' scores on the intelligibility test will be compared by separating the tokens according to (1) vowel type (/ɪ/ and /i/), and (2) F1 value range (one SD below or above the English native speakers' mean and close to the English native speakers' mean). The results will be separated according to each criterion set, 0 and 1 will signalize if the listener transcribed the token appropriately according to the vowel type (0 = not appropriately; 1 = appropriately). Then, the mean scores of correct responses for each vowel, separated by F1 ranges, will be calculated and compared. As the F1 criterion has not been used in previous studies, this hypothesis is exploratory.

RQ3: How are the listeners' proficiency level related to their performance on the intelligibility test scores, at both vowel and word levels?

H3: The higher the listeners' proficiency level, the better their performance on the intelligibility test.

I expect to find a positive correlation between the listeners' scores, as measured by the Oxford Placement Test, and their performance on the intelligibility test. As suggested by previous research (Bent & Bradlow, 2003;

van Wijngaarden et al., 2002), L2 proficiency has a major impact on speech intelligibility.

In order to correlate the results of the intelligibility test and the proficiency test, I will run correlations for the results from the intelligibility test, separating the data according to vowel and word level, and to vowel type, which will be correlated with listeners' proficiency test raw scores.

RQ4: Does word familiarity correlate with lexical frequency and with listeners' performance on the intelligibility test?

H4: Word familiarity, lexical frequency and intelligibility test scores are correlated.

Little previous research has provided insight on how word familiarity can affect word intelligibility. Bradlow and Pisoni (1999), and Bradlow and Bent (2003) posit that non-native word recognition accuracy is affected by word familiarity.

This hypothesis will be tested by running correlations, using the word familiarity test rates, lexical frequency data, and the intelligibility test scores. Similar to hypothesis 3, in this analysis the correlations will be run separating the data according to vowel type at the vowel and word level.

RQ5: How does the listeners' length of residence (LOR) correlate with their performance on the intelligibility test, at both vowel and word levels?

H5: Listeners who had been longer in Brazil will be more attuned to speakers' accent, and, thus, accent familiarity will positively influence listeners' performance on the intelligibility test.

Even though previous research has had opposing results (Cruz, 2008; Munro et al., 2006; Schadech, 2013), I expect the speakers who had been in Brazil longer, and thus are more accustomed to Brazilian-accented English, to have higher scores at both vowel and word level on the intelligibility assessment.

I will run correlations using the results from the intelligibility test, according to vowel/word level and vowel type, which will be correlated with listeners' LOR in Brazil.

For all statistical analyses, the program SPSS (Version 16) will be used and the *p* value will be set at .05 (Larson-Hall, 2010). Before deciding on the statistical tests to be used, all variables will be examined using descriptive statistics and normality tests in order to check whether the variables are normally distributed or not.

Summary of the chapter

This chapter addressed the methodological concerns of the present study. Firstly, vowel production participants were presented, and the procedures for developing production data gathering instruments and for analyzing data were carefully explained. Then, listeners' profiles were presented and all issues regarding the intelligibility measures (tests design, and procedures) were discussed. Lastly, the research questions and hypotheses which guide this study were presented.

In the next chapter, the study findings are reported and discussed in the light of the literature summarized in Chapter 2. The results are presented in an attempt to answer each research question and hypothesis.

CHAPTER FOUR

RESULTS AND DISCUSSION

In this chapter, results are presented and discussed taking into account the literature summarized in Chapter 2. To do so, the hypotheses are revisited and discussed, while reporting relevant results and discussing to what extent they corroborate each hypothesis. Detailed information about the statistical tests used can be found in the footnotes as indicated throughout the chapter. The chapter is organized according to the order that the research questions and hypotheses have been posed in the previous chapter.

4.1 Vowel intelligibility (H1)

In order to evaluate how intelligible the English high front vowels produced by the BPSE were, and thus, to reflect on the role these vowels play in speech decoding, it was hypothesized that both vowels would cause intelligibility problems at both vowel level (when just the vocalic segment was taken into account), and at word level (when the whole word was accounted for). Results indicate a tendency for the tense vowel to pose more difficulty to the listeners, both at word and vowel level. Before discussing the results, Figure 10, which displays the means of correct responses for each vowel at both levels in the intelligibility test, shall be considered.

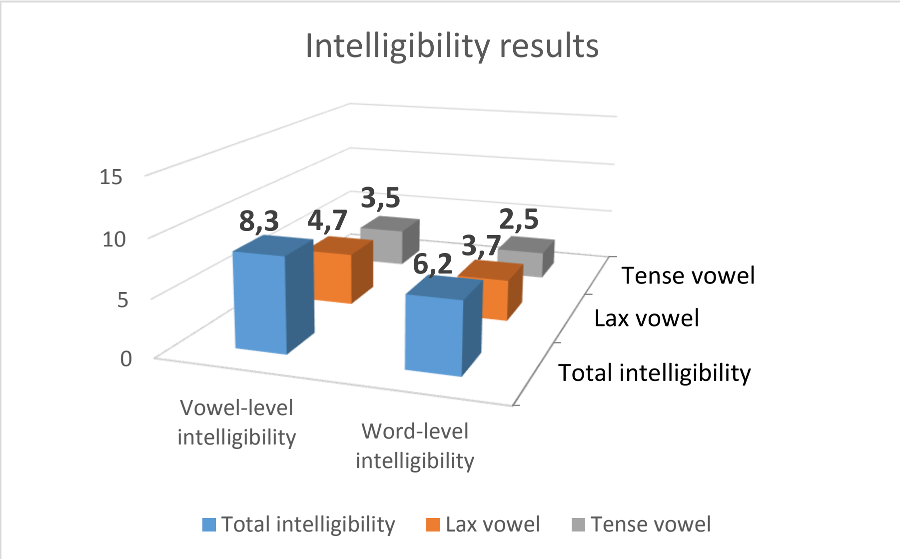

Figure 10. Means from the intelligibility test separated by vowel type at vowel and word levels

As explained in the method chapter, the intelligibility test presented 35 tokens, 20 of which contained the English high front vowels. 15 tokens were used to assess intelligibility, and the other five were used to observe listeners' performance towards native tokens, and listeners' reliability. Figure 10 presents the results for all the 15 tokens from the intelligibility test. Specific analyses of the listeners' performance with the native tokens and with the tokens used to check for reliability are presented later in this section.

In general lines, transcriptions were more accurate at the vowel level (55%, *M:* 8.3) than at the word level, which could indicate that the listeners had a better performance in recognizing the vowels than the entire words containing the target vowels. At word level, the rate of correct word transcription was lower (41%, *M:* 6.2), likely due to the occurrence of phonological processes of transfer from BP, which were identified in the words used in the stimuli. As regards the transcription of each vowel at vowel and word levels, the tense vowel posed more difficulty for listeners (43%, *M:* 3.5; and 31%, *M:* 2.5; of correct responses, respectively). The lax vowel had moderate rates of intelligibility at both levels: 67% (*M:* 4.7) and 53% (*M:* 3.7), respectively.

Taking up on the phonological processes found in the speakers' production that hindered intelligibility, by conducting a perceptual-auditory analysis, the researcher was able to identify the occurrence of palatalization, vowel paragoge, and deaspiration of initial stops. These processes influenced the transcriptions provided by some listeners, and therefore affected intelligibility, as can be seen in Table 8.

Table 8

Phonological processes that hindered intelligibility

Phonological process	Speakers' production	Target word	Listener's transcription	Occurrence in transcriptions
Palatalization + vowel paragoge	[ˈbitʃɪ]	bit	beach (1) peach (1)	6,2 %
Deaspiration + palatalization + vowel paragoge	[ˈpitʃɪ]	Pete	beach (6) bitch (3) each (1) peach (10) pitch (5)	Deaspiration: 28% Palatalization: 78%
Deaspiration + palatalization	[ˈpitʃ]	pit	beach (8) beaches (2) bitch (1) each (5) peach (1) pitch (2)	Deaspiration: 34% Palatalization: 59%
Vowel paragoge	[ˈpikɪ]	pick	pig (3)	9 %

It is common knowledge that phonological processes that result from L1 transfer (e.g., deaspiration of voiceless plosives, palatalization, vowel paragoge) are present in the speech of BPSE (Zimmer, Silveira, & Alves, 2009).

Following the categories proposed by Cho and Ladefoged (1999) for classifying *Voice Onset Time* - VOT – (the time between the release of a stop constriction and the onset of voicing on the following vowel), voiceless stops in BP would be classified as slightly aspirated for having VOT < 54ms. AE voiceless stops would be characterized as aspirated for having VOT means between 55-94ms.

By carrying out a perceptual-auditory inspection on the tokens included in the intelligibility test stimuli, the experimenter verified that the speakers from this study did not aspirate voiceless stops in initial position when producing them. The deaspiration of initial stops compromised the intelligibility of the tested words according to listeners' judgment. In the case of 'Pete', which can be observed in Table 8, the deaspiration of the initial [p] led listeners to transcribe words containing its voiced counterpart, [b], such as 'beach' and 'bitch'. This process accounts for 28% of occurrence in the listeners' transcriptions for this specific token. Another case in which the deaspiration of initial plosives hindered intelligibility was the token 'pit', which was transcribed with words containing the voiced initial plosive ("beach", "bitch") in 34% of listeners' transcriptions for this specific item.

The occurrence of vowel paragoge in BP interphonology is explained by the fact that a BP canonic syllable is CV (Carlisle, 1994; Câmara Jr., 1970). Thus, syllable simplification occurs when a CVC syllable is turned into CV.CV syllables (Silveira, 2004), for instance, when 'beat' ([bit]) is produced as /ˈbiti/. Moreover, as Cristófaro-Silva (2010) posits, [t] and [tʃ] are allophones in a number of BP dialects when they are followed by [i]. Thus, the substitution of [tʃ] for [t] does not result in contrasts among lexical items in BP.

Table 8 evidences that palatalization and vowel paragoge also frequently resulted in unintelligible speech. When the final /t/ in the target word ‘Pete’ was palatalized, 78% of the listeners’ transcriptions were inaccurate and included a word ending in [tʃ] (e.g., ‘peach’). That is a clue for the fact that listeners might not have been aware that the transfer of this BP phonological process is frequent in the English spoken by Brazilian learners. Similarly, the final [t] in ‘pit’, when palatalized and followed by an epenthetic vowel, yielded 59% of transcriptions containing a final [tʃ] (e.g., ‘beach’). These results indicate that processes of transfer from BP into English are to play a major role in speech intelligibility, especially regarding the palatalization of final voiceless consonants.

Furthermore, by looking at the words transcribed by the listeners, one can say that they did not provide transcriptions that resulted in sentences that were accurate at the syntactic level or that made sense at the semantic level. Given the pronunciation deviances present in the stimuli, it is likely that listeners assumed that they were listening to low-proficiency users of English, whose speech could also contain errors at other speech levels. By looking at the word choices listeners made, it is possible to state that they searched for a lexical item which would best fit the stimulus they had just heard, and apparently they did not take into account the meaning conveyed by the sentence in which such item would be included.

Listeners chose words such as ‘beach’, ‘each’, and ‘pitch’ to complete the sentence “Give it to…” which do not assign any meaning to the utterance. This might be one of the drawbacks in having a “fill in the gaps” intelligibility test. However, in order to test for specific acoustic cues and their effect on vowel intelligibility, this technique has been suggested as appropriate (Munro & Derwing, 1995; Derwing & Munro, 1997; Schadech, 2013).

One of the examiners in the evaluation committee brought to my attention another aspect worth of consideration. Taking into account the target words, it is possible to see that the spelling pattern for the lax vowel, ‘i’, is simpler than that used for the tense vowel, ‘ea’ and ‘ee’. In this sense, listeners, not knowing how to distinguish between the two vowels, tended to go for the simplest spelling. Thus, if there was not intelligibility in the stimulus they heard, listeners may have tended to use the lax spelling pattern. Also, it appears to me that proficiency is an individual trait that could have influenced the use of such strategy. Reliance on spelling knowledge (orthography) and its relationship with L2 proficiency could constitute the focus of further research in the field.

Jenkins (2002) discusses that when both speaker and receiver are non-native, they tend to rely more on the acoustic signal. Thus, when the availability of the cotextual clues does not tally with what they heard in the signal, they are likely to adjust (or adapt) the cotext to bring it into line with the acoustic signal. This demonstrates that non-native listeners might consider the phonological level more important than the semantic and the lexical levels, which tend to be modified or even neglected to fit available acoustic information. When non-native listeners are not given the chance to adjust the cotext in a closed intelligibility test, they still tend to make lexical choices based on the available acoustic signal, in an attempt to match the lexical level to the phonological level - even if, in order to do that, semantics is ignored, and only acoustic information is decoded, which was the case in the present study. This behavior of listeners draws attention to the need for more empirical research in the area of intelligibility so that more accurate instruments for assessing this dimension are made available.

Another important observation is the choice for the word ‘pig’ to complete the sentence “Can you take your...?”. The word uttered by the speaker was ‘pick’, with no voicing, but ending with an epenthetic vowel [ˈpiki]. Listeners might have been sensitive to the difference in aspiration in the /k/ produced by the speaker, and thus opted for its voiced counterpart, /g/, in order to complete the sentence. Notwithstanding, this time ‘pig’ was a meaningful choice, regardless the unlikelihood of the sentence “Can you take your pig?”. Given the small percentage of occurrence of this word to complete this specific sentence (9%), it is not possible to state exactly what influenced listeners the most: the choice of a word similar to what they heard in the stimulus that would complete the sentence meaningfully, or any differences in the acoustic quality of /k/ that might have influenced perception. Thus, perception in this case appears to play a relevant role in intelligibility studies. A research design which makes use of both intelligibility and perception tasks with the same stimuli might be able to provide more accurate answers.

As regards the statistical procedures to test Hypothesis 1, first I observed whether the tested variables were normally distributed by obtaining descriptive statistics (mean, standard deviation, percentages, minimum and maximum scores). Table 9 brings the descriptive statistics of the intelligibility test for the high front vowels at vowel and word level. The maximum score possible for the intelligibility test was 15.

Table 9
Descriptive statistics for the intelligibility test at both word and vowel level

	Vowel level intelligibility				Word level intelligibility			
	Mean	**%[a]**	SD	Min-Max	Mean	%[a]	SD	Min-Max
/i/	3,5	43%	1,9	1-7	2,5	31%	1,8	0-6
/ɪ/	4,7	67%	1,5	2-7	3,7	53%	1,3	2-8
Total intelligibility	8,3	55%	1,9	4-13	6,2	41%	2,1	2-11

[a] Percentage of correct responses

As previously discussed, the results indicate that the tense vowel [i] posed more difficulty to listeners at both vowel and word levels. It is interesting to point out that the standard deviation values for the tense vowel are higher than for the lax vowel, thus, indicating higher variability in the listeners' performance in the case of the tokens with the tense vowel.

Normality tests indicated that the intelligibility variables were not normally distributed (check table in Appendix N). Thus, non-parametric tests were run to compare if the mean differences observed for the two levels (vowel and word levels) reached significance. Wilcoxon[39] signed rank tests were run to compare different vowels within the same level (/i/-/ɪ/ at vowel level, and /i/-/ɪ/ at word level). The tests showed that the differences in the means for each variable in the intelligibility test are significant at both vowel level (z = -2,15; p = .031), and at word level (z = -2,63; p = .008).

To compare the same vowels across levels (/i/-/i/ at vowel and word level, and /ɪ/-/ɪ/ at vowel and word level), Wilcoxon signed rank testes were run. The tests revealed that the differences in the means for each variable in the

[39] Wilcoxon tests are used to compare the performance of a group of participants on two tests, in this case, listeners' transcriptions at word and vowel level, for each of the vowels. This test is the non-parametric equivalent of a related-samples t-test (Larson-Hall, 2010).

intelligibility test are, once more, significant across vowel and word levels for /i/ (z= -4.12; p= .000), and for /ɪ/ (z= -3.78; p= .000).

In general lines, both vowels had low means of accurate transcriptions, showing that the listeners had difficulty identifying them. Moreover, the listeners struggled more with the high tense vowel, which had the lowest means. The overall results are in accordance with what Cruz (2012a) and Becker (2013) mentioned how the lack of contrast between high front vowels can hinder speech intelligibility. These vowels are also contemplated in the LFC proposed by Jenkins (2002), which shows that being able to distinguish between tense and lax vowels is crucial for mutual intelligibility. Yet, it was found that there are other speech features worth of attention as regards the construct of intelligibility, such as the effects of transfer of BP phonological processes into English. Therefore, Hypothesis 1, which stated that both vowels would cause intelligibility problems, was corroborated. Now, I shall discuss listener-reliability.

To test for listener-reliability, three tokens provided by a native speaker of English were included in the intelligibility test. Also, one sentence provided by the same BP speaker of English was repeated once. Table 10 displays the number of tokens taken into account for the listener-reliability analysis and the number of correct transcriptions, separated by vowel type. Note that the NSE data encompassed both one word with the tense vowel (‘beat’), and two words with the lax vowel (‘kick’ and ‘sit’).

Table 10

Descriptive statistics for the intelligibility of tokens provided by a NSE used to check for listener-reliability

	Vowel level intelligibility				Word level intelligibility			
	Mean	%[a]	SD	Min-Max	Mean	%[a]	SD	Min-Max
/i/	0.84	84%	0.36	0-1	0.56	56%	0.50	0-1
/ɪ/	1.71	85.5%	0.52	0-2	1.68	84%	0.59	0-2
Total intelligibility	2.5	85%	0.75	0-3	2.25	75%	0.80	0-3

[a] Percentage of correct responses

The NSE tokens were not repeated in the test, as the objective of including them was to observe possible bias towards the data (i.e., listeners would assume the data set contained only tokens produced by NNSE and not focus on the test as expected), as well the extent to which the tense/lax contrast was difficult for the listeners. Interestingly, NNL had little difficulty in identifying the vowels provided by the NSE, as total intelligibility for these tokens were considerably high at both vowel level (85% of correct responses) and word level (75%). Considering each vowel type, at vowel level both vowels had quite similar high rates of correct transcriptions (tense: 84%; lax: 85.5%). At the word level, the transcriptions for the lax vowel [ɪ] was, again, very high and quite similar to its rate of correct transcriptions at the vowel level (vowel level: 85,5%; word level: 84%). Differently, with the tense vowel the rate of correct transcriptions at word level was significantly lower when compared to its rate of correct transcriptions at vowel level (vowel level: 84%; word level: 56%). Listeners had a worse performance in transcribing the carrier word 'beat' due to the fact that the NSE produced this word with unreleased final [t]. Many listeners were unaware that this process is common in American English and transcribed the word as 'bee', which meaningfully completed the sentence "can you hear the…?". Thus, in this specific case, [t] as an unreleased consonant hindered speech intelligibility. However, an intelligibility test that focuses on the intelligibility of such aspect would be necessary in order for a researcher to draw generalizations on this case.

When the performance of listeners transcribing tokens provided by BPSE is compared to their performance transcribing tokens provided by a NSE, it is possible to observe that listeners performed substantially better with the NSE tokens. Table 11 displays the rates of correct transcriptions for each level of intelligibility analyzed, considering specifically NSE and BPSE tokens.

Table 11

Percentage of correct transcriptions for BPSE and NSE tokens according to each intelligibility level

	Vowel level Intelligibility		Word level intelligibility	
	% BPSE	% NSE	% BPSE	% NSE
/i/	43%	84%	31%	56%
/ɪ/	67%	85,5%	53%	84%
Total intelligibility	55%	85%	41%	75%

Higher rates of correct transcriptions are found at vowel level, showing that listeners were more sensitive to acoustic differences present in the NSE vowels, possibly, different durational values, as previously discussed in Section 3.3.2. Again, at word level, the rates of correct transcriptions were higher, even for the case in which 'beat' was produced with an unreleased final consonant and considerably affected listeners' performance. At word level, BPSE speech tokens presented phonological processes of transfer from BP, such as palatalization followed by the insertion of an epenthetic vowel, which caused intelligibility to be seriously compromised.

Continuing with the listeners' reliability analysis, one token provided by a BPSE was repeated in the intelligibility test, as the analysis of these results could demonstrate listeners' consistency in transcribing the BPSE speech tokens. It was firstly included as number 16 in the intelligibility test, and then repeated as number 32 towards the end of it. Both times 'beat' had the exact number of correct transcriptions: 19, which accounts for almost 60% of correct transcriptions, similarly to what was obtained in the overall results for speech intelligibility of BPSE, as already demonstrated in Table 9. A Spearman correlation was run and demonstrated that the relationship between listeners' transcriptions for each time that the token 'beat' was played in the intelligibility test was moderate (*rho* = .611) and significant (*p* = .000), attesting for the listeners' consistency when taking the test. Thus, regarding listeners' reliability, two conclusions can be drawn. First, they were not biased towards the data, since their performance with the NSE tokens was better. Second, the listeners tended to be consistent when transcribing the same BPSE token twice. Now, I shall report the results obtained for the second research question, which addresses the effects of vowels spectral proximity on intelligibility.

4.2 Effects of spectral proximity on vowel intelligibility (H2)

To provide insight on vowel acoustic features that play a role on intelligibility, the tokens selected for the intelligibility test displayed specific F1 values, which were chosen based on the F1 criterion (above 1SD, below 1SD, or close to the mean reported for English monolinguals – see Section 3.3.3). As can be seen in Section 3.3.3, the dataset taken into account to come up with a baseline for this experiment was gathered by Rauber (2006), and encompassed English monolingual speakers' data. Hypothesis 2 predicted that the high front vowels produced by BP speakers with F1 values which are further from the mean of English monolinguals (as reported by Rauber, 2006), either one standard deviation below or above, would be misidentified the most and, thus, affect intelligibility more. It is important to restate that most vowels produced by the BPSE had high F1 means, as they tended to approach the means of the native tense high front vowel (see section 3.3.2). Thus, it was difficult for the experimenter to find tokens which were below 1SD. By inspecting token by token, an alternative was to build the test looking for minimal pairs ('beat' – 'bit') according to each criteria (above 1SD – below 1SD). Thus, this is the reason why each acoustic criterion (1SD below or above) presents a specific vowel type, as can be seen in Table 12.

Table 12 shows the number of correct responses in the intelligibility test according to the F1 value of the vowel in the target words, separated by vowel type.

Table 12

Number of correct responses in the intelligibility test for vowel level according to the F1 acoustic criteria

	N of tokens with /i/	% of correct transcriptions for /i/	N of tokens with /ɪ/	% of correct transcriptions for /ɪ/
Below 1SD	--	--	160	75% (121)
Above 1S	160	46% (75)	--	--
Close to the mean	96	39% (38)	64	70% (45)

In general lines, Table 12 demonstrates that the lax vowel was considered to be more intelligible by the listeners, no matter which acoustic criterion was applied to the token selection. As regards tokens in which the F1 value was 1SD below the mean, all of them presented words which had the grapheme < i > representing the target lax vowel /ɪ/. This was the criterion that provided the most intelligible tokens with 75% of correct responses. In regard to tokens in which the F1 was 1SD above the mean, all of them presented words which had the graphemes < ee > and < ea > representing the target tense vowel /i/. Listeners had a weak performance in classifying this vowel as the results showed only 46% of correct responses. In relation to tokens in which the F1 values were close to the NSE mean, they had both target tense and lax vowels.

The tense vowel again had lower percentages of correct responses (39%) than the lax vowel (71%).

In general lines, as the vowels supplied by the NSE were the ones which presented the high front vowel pair with distinguishing durational cues (see section 3.3.2), and the tokens provided by the BPSE did not differentiate one vowel from the other in terms of duration, listeners might have possibly relied more on temporal cues to identify the L2 vowels. Moreover, considering that both of the high front vowels produced by the BPSE had shorter and similar durations, there was a tendency for /i/ to be misidentified as the lax counterpart /ɪ/, the category which is expected to present shorter temporal cues. On the other hand, highly frequent words, which coincidently carry the lax vowel (see Section 3.2 and discussion in Section 4.2) were also the most intelligible words. Thus, apparently listeners' reliance on durational cues went hand in hand with the frequency of the tested words. Both variables, listeners' reliance on duration and word frequency, might have led to the higher number of correct transcriptions for the lax vowel in the intelligibility test.

Hypothesis 2, which stated that vowels with F1 values 1 SD above or below the mean would hinder intelligibility was not confirmed. As discussed in this section, vowel type was an important factor, with the words containing the tense vowel imposing greater difficulties to the listener, no matter what F1 criterion was used. Moreover, vowel duration seemed to have played an important role as well, as the words containing the tense vowel were often transcribed as words with the lax vowel, thus indicating that because BP speakers produced /i/

with short duration (*M* for female and male speakers: 97ms), listeners tended to hear it as /ɪ/. Now, I shall discuss the results of RQ3, which dealt with effects of listeners' proficiency on intelligibility.

4.3 The relationship between listeners' L2 proficiency and vowel intelligibility (H3)

To gain insight into the role of individual differences and their relationship with speech intelligibility, two variables related to the listeners were investigated, namely L2 proficiency, and length of residence as an indirect measure of speech familiarity (to be discussed in Section 4.5). To investigate effects of listeners' proficiency, it was hypothesized that the higher the listeners' proficiency level, the better their performance on the intelligibility test would be.

Overall, listeners' proficiency level contributed to speech intelligibility. Figure 11 displays the intelligibility means of correct responses at vowel-level and at word-level according to listeners' proficiency level.

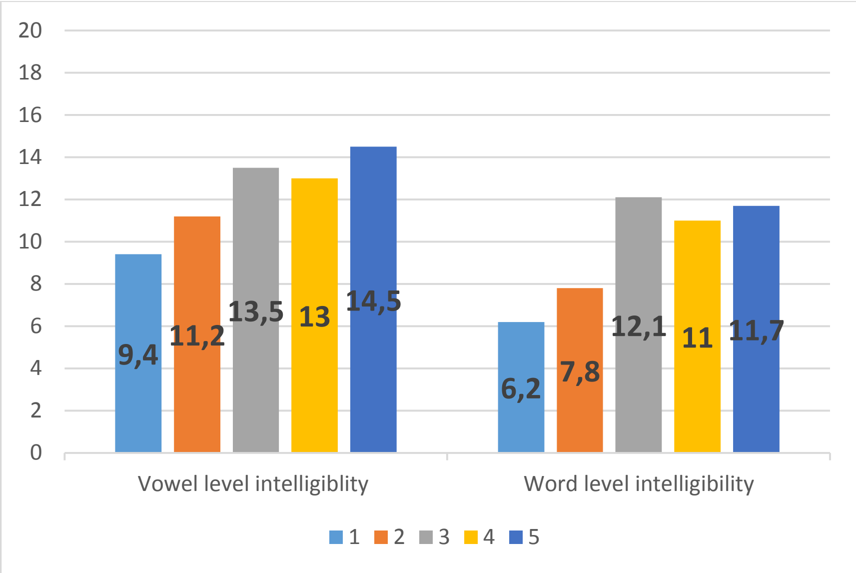

Figure 11. Intelligibility means according to listeners' proficiency level (1-5)

At both levels, there was a tendency for the intelligibility scores to increase along with the listeners' proficiency level. However, subjects from proficiency level 3 outperformed the subjects from proficiency level 4. At word level, subjects from proficiency level 3 outperformed all subsequent levels (4 and 5).

When it comes to the scores of the proficiency test taken by the listeners, normality tests indicated that the data did not present normal distribution (Smirnov p = .003; Shapiro –Wilk p = .001). After separating the results by vowel type, as well as by vowel and word levels, Spearman correlations between the proficiency test scores and intelligibility test were run to observe whether these variables were related. Table 13 displays the results for these correlations, at vowel level, for each vowel separately.

Table 13

Raw score of listeners' proficiency level correlated to vowel level intelligibility

	Vowel-correct responses /i/	Vowel-correct responses /ɪ/
Correlation Coefficient	.538**	.186
Sig. (2-tailed)	.002	.307

Table 13 shows that the strength of the relationship between speakers' proficiency level and correct responses for vowel level /i/ is moderate (*rho* = .538) and significant (*p* = .002), attesting for the assumption that the higher the listeners' proficiency level were, the higher the number of correct responses in the intelligibility test for the tense vowel. Section 4.1 shows that the tense vowel generally posed more difficulty for listeners. Thus, the proficiency level contributed notably for its intelligibility, as more proficient listeners were able to transcribe this vowel more successfully.

Spearman correlation results displayed in Table 13 also revealed that listeners' proficiency level did not influence the intelligibility of the vowel /ɪ/, given that a weak, non-significant correlation coefficient was obtained (*rho* = .186; *p* = .307). Section 4.1 shows that this vowel had higher intelligibility rates, therefore, there was a tendency for listeners to transcribe the lax vowel more successfully, no matter what proficiency level they had. Thus, for the transcription of the lax vowel, proficiency did not play an important role.

Spearman correlations were also run to look at the relationship between listeners' proficiency and word level intelligibility for each vowel. The results are presented in Table 14.

Table14

Raw score of the proficiency level correlated to word level intelligibility

	Word-correct responses /i/	Word-correct responses /ɪ/
Correlation Coefficient	.643**	.433*
Sig. (2-tailed)	.000	.013

For the intelligibility of words with the tense vowel, a moderate, significant relationship with listeners' proficiency was found (*rho* = .643; *p* = .000). This means that the higher the listeners' proficiency level, the easier it was to recognize words with the tense vowel, similarly to the results obtained at vowel level.

Concerning the intelligibility of words with the lax vowel, a moderate, significant relationship with listeners' proficiency was found (*rho* = .433; *p* = .013). This means that proficiency is significantly correlated with the recognition of words with the lax vowel, differently from the results obtained at vowel level.

In general lines, only more proficient listeners were able to identify the tense vowel, as the lax vowel was generally well-identified by all listeners, no matter what proficiency level they had. At word level, proficiency was significantly correlated to the number of correct transcriptions of words with any of the two vowels tested. This is because more proficient listeners were aware of the fact that the speakers had pronunciation difficulties and, thus, tended to interpret the stimuli considering their difficulties. Also, more proficient listeners were attuned with the phonological traits (processes from BP) which were present in the target words, and notably did not let these processes influence their transcriptions.

Therefore, Hypothesis 3 was partially corroborated at the vowel level and fully corroborated at the word level. Now, I shall look at the results of RQ4, which dealt with effects of lexical familiarity and lexical frequency over intelligibility.

4.4 The relationship between listeners' lexical familiarity, lexical frequency and vowel intelligibility (H4)

Hypothesis 4 predicted that word familiarity and intelligibility test scores would be correlated. Table 15 displays the tested words according to their rank of frequency (RoF), listeners' familiarity rates, and intelligibility scores. Frequency values were obtained from COCA, in which the higher the number, the more frequent the word is in the corpus. Moreover, listeners' familiarity, measured with the help of a scale, indicates the degree of familiarity the listeners reported for the target words included in the intelligibility test. Intelligibility percentages are also displayed in Table 15 to make it easier for the reader to observe how the three variables (word frequency, word familiarity and intelligibility) are related. Some words, spoken by different BP speakers, had to be repeated in the intelligibility test, so that the acoustic criterion used for token selection could be followed (Section 3.3.3), and, in Table 15, the results for the repeated words appear in the last two columns.

Table 15

Frequency rank, familiarity, and intelligibility of the tested words

	Frequency in COCA	Speakers' familiarity means	Intelligibility (first time)	Intelligibility (second time)	Intelligibility (third time)
bit	83,131	3	81%	78%	
sit	45,762	3	81%	78%	
pick	42,739	3	12.5%	34%	37.5%
beat	40,572	3	59%	59%	53%
seat	35,594	3	37.5%	53%	
peak	12,597	3	50%	50%	
kick	12,050	3	90%	94%	
Pete	11,318	3	3%		

pit	6,782	2.5	0	
keak	4	0	0	0

As this analysis includes two ordinal variables (word familiarity ratings and percentage of intelligibility), Spearman correlations were run. First, Spearman was run to examine if word familiarity and word frequency were related to one another and could be seen as different variables. The output revealed that the correlation between word familiarity and word frequency is strong (*rho* = .701), and significant (*p* = .024). However, one discrepancy was found. Highly frequent words, such as 'bit' and 'sit', received a rating of three on the familiarity scale, which indicated that the listeners were very familiar with these lexical items (and also knew their meaning and had seen them before, for three was the highest level on the familiarity scale). However, words with lower frequency, such as 'kick' and 'Pete', which had frequency values that differed substantially from the high frequent items, were also assigned the maximum rate (3) by the listeners. This reveals that familiarity might not be accurately measured on a four-level scale, as listeners end up having few options on the scale. Yet, as most of the words tested were highly frequent, this led listeners to assign 3 to many of the lexical items (very familiar items), making most words fall into the same category, even if these words had a lower frequency rank in the COCA corpus. Overall, word frequency was positively correlated with familiarity. However, only items with notably lower frequency ('pit' and 'keak') received low rates regarding familiarity. (*M = 2.5,* and *0*, respectively).

Familiarity was also correlated to intelligibility, as the Spearman test between lexical familiarity and correct responses in the intelligibility test was moderate to strong (*rho* = .696), and significant (p = .025). In general lines, word familiarity appears to be a good predictor of listeners' performance on the intelligibility test. From the ten tested words, five which were assigned the maximum rate on the familiarity rating scale tended to have the higher percentage of correct transcriptions in the intelligibility test (first time the words were tested), for all of them yielded more than 50% of correct responses ('bit', 'beat', 'sit', 'kick', 'peak'). However, listeners poorly identified the words 'seat', 'pick', and 'Pete', which were also considered to be very familiar items ($M = 3$). Similarly, in the case of the words 'pit' and 'keak', which had lower means in the familiarity test (mean rating*:* 2.5, and 0, respectively), listeners had their performance considerably affected, for no listener managed to transcribe them correctly, attesting for the effect of familiarity on intelligibility.

Regarding the correlation between intelligibility results and lexical frequency, the Spearman coefficient was moderate (*rho* = .652), and significant (p = .041). The word with the highest intelligibility score was 'kick' (90%), which was the seventh in the frequency rank. 'Bit' and 'sit' were the second and third most intelligible words, considering how well recognized they were (81%), and these words were the two most frequent. The relationship between frequency and intelligibility is clearer when it comes to low frequency items (which were also less familiar to the listeners), such as the case of 'Pete', 'pit', and 'keak' (3% of correct responses in the intelligibility test, 0%, and 0%, respectively). Yet, the most intelligible items carry the lax vowel (‘kick’, ‘sit’, ‘bit’), and two of these are the most frequent words (‘sit’ and ‘bit’), which could help to explain why words containing the lax vowel yielded the highest percentages of correct transcriptions in the intelligibility test.

As regards the condition of repetition of a lexical item in the stimuli used for the intelligibility test, being disregarded the acoustic criterion applied to the selection of the token, it is not possible to state that any positive or negative effects were found. In some cases (‘bit’ and ‘sit’, 81% to 78%) speech intelligibility decreased, whereas in others (‘pick’ – 12,5% to 34% to 37.5%, and ‘kick’, 90% - 94%) it increased, whereas in others (‘peak’, 50%-50%) it remained the same. Possibly, some of the different results here are related to the fact that repeated words were produced by different speakers and therefore contained different phonetic details, which influenced intelligibility results in different ways.

Derwing and Munro (2005) claim that the cotext is an important variable in intelligibility assessment. In the present study, all the sentences in which the carrier words should be transcribed were presented in the test worksheet, so that listeners would have this information available when taking the test. In the present study, all the sentences used were meaningful so that unintelligibility was not facilitated. Also, the examiner did not want to make use of isolated words. Notwithstanding, the cotext migh have caused the effect of priming for certain words. Cotext priming addresses the fact that certain words can be predicted just by looking at the sentences. Considering the sentences of the present study, they might have primed certain words, as the examples below illustrate: And now can you (sit)?; Can you wait a (bit)?; Hear the (beat). I consider that these sentences presented a priming effect given the fact that the words used with them are very likely to appear in this linguistic context. Thus, listeners could have heavily relied on previous knowledge to complete these specific sentences and not relied on the acoustic signal. Consequently, cotext priming might have influenced the results for the intelligibility test. One of the suggestions to control for this variable is having meaningful sentences that carry words which are not primed to be inserted in those specific linguistic environments.

In general lines, word frequency can be a good predictor for speech intelligibility, attesting for the influence that frequency has on tasks that involve speech decoding. Moreover, frequency and familiarity appear to be notably intertwined with intelligibility, as indicated by the moderate and significant correlations. Therefore, Hypothesis 4 was supported. Now, I shall discuss the results of the last RQ, which sought to provide insights on the relationship between listeners’ length of residence in Brazil and intelligibility scores.

4.5 The relationship between listeners’ length of residence and vowel intelligibility (H5)

In order to understand if familiarity with one’s accent is beneficial for speech intelligibility, listeners’ length of residence (LOR) was correlated with their scores in the intelligibility test. It was hypothesized that length of residence would positively correlate with listeners' performance on the intelligibility test. Listeners' LOR in Brazil ranged from 2 weeks to 80 months (*M:* 16 months). Spearman correlations were run to check for correlations between the number of correct answers in the intelligibility test, at both word level and vowel level, and the listeners' LOR.

Table 16

Correlations between LOR and vowel and word level intelligibility

	Correlation coefficient (*rho)*	*p.* value
Total correct resp. vowel level	.015	.934
Vowel-correct responses /i/	.068	.711
Vowel-correct responses /ɪ/	-.028	.877
Total correct resp. word level	-.149	.415
Word-correct responses /i/	-.088	.633
Word-correct responses /ɪ/	-.050	.785

At both vowel and word levels, the results shown in Table 16 indicate that there was no important relationship between listeners' LOR and their scores in the intelligibility test. All correlations were extremely weak and non-significant, showing that length of residence is not a good predictor of performance on the intelligibility test.

Due to the lack of significant results for this analysis, it is believed that length of residence is not an accurate indicator of familiarity with Brazilian Portuguese-accented-English. This might have happened given the fact that these participants use Portuguese to communicate with other Brazilians, and not English. Regrettably, the amount of usage of L2 Portuguese by these participants in Brazil was not assessed in the questionnaire. Notwithstanding, the overall results for this RQ corroborate those found by Munro et al. (2006), and Schadech (2013), as these authors found no significant relationship between length of residence and speech intelligibility. Therefore, Hypothesis 5 was not confirmed.

Summary of the chapter

This chapter presented the results for all the research questions of the present study. Research question number one demonstrated that when it comes to transcribing vowels as an index of speech intelligibility, listeners from a number of L1s had more difficulty transcribing words that contained the tense vowel at vowel level. Yet, at word level intelligibility was compromised more often as it was found that phonological processes transferred from BP into English (such as consonant devoicing and palatalization) posed great influence on speech intelligibility, and very frequently hindered listeners' understanding of utterances. Research question number two demonstrated that listeners from the present study were not sensitive to changes in the spectral frequencies of the tested vowels, and overall seemed to have relied on duration in order to distinguish the high front vowel pair. Research question number three sought to look at issues regarding listeners' individual differences, namely, their level of proficiency, which often correlated well with the number of correct responses in the intelligibility test. In research question number four, the role of lexical frequency and listeners' familiarity with lexicon were investigated. Results showed that more frequent words were usually more intelligible, and had higher familiarity ratings. Research question number five that investigated the relationship of listeners' length of residence and intelligibility found no significant results. Having briefly summarized the results discussed in this chapter, I shall now present the conclusion of the present study.

CHAPTER FIVE
CONCLUSION

The objective of this chapter is to summarize the main results presented throughout the previous chapter, as well as discuss the pedagogical implications of these findings, the limitations of the study and suggestions that may contribute to future research on intelligibility.

5.1. Summary of overall results

Research question number one demonstrated that when it comes to transcribing lexical items as an index of speech intelligibility, listeners from a number of different L1s had more difficulty transcribing words with the tense high front vowel at vowel level. Yet, at word level intelligibility was compromised more often as it was found that phonological processes of transfer from BP into English (such as consonant devoicing and palatalization) posed great influence to speech intelligibility, and very frequently hindered listeners' understanding of utterances. In addition, results from this research question demonstrate that research can profit from investigations on intelligibility carried out at different levels (word and vowel level, as in the case of the present study), as the results obtained for each level tend to differ.

Research question number two demonstrated that listeners from the present study were not sensitive to differences in one of the spectral frequencies (F1) of the tested vowels, and overall tended to rely on duration in order to distinguish the high front vowel pair. Notwithstanding, the results from these two research questions demonstrate how production is intertwined to speech intelligibility. As vowels were not accurately distinguished by speakers when producing them, the same reflected on listeners' performance when they tended to rely on durational cues to transcribe words with lax and tense vowels. Vowels produced by the BP speakers did not present a distinction in acoustic duration for this parameter to be salient enough for listeners to be able to separate one category from the other, and thus, there was a tendency for both vowels to be transcribed as the lax counterpart. Thus, vowel duration, at least for the high front vowel pair, is indeed relevant of receiving attention in intelligibility-oriented instructional approaches, thus, reinforcing Jenkins' (2002) claims.

Research question number three sought to look at issues regarding listeners' individual differences, namely, their level of proficiency and its relationship with speech intelligibility. Correlations demonstrated that at the vowel level, listeners' proficiency correlated well only with the tense vowel (more proficient listeners were more successful in transcribing this vowel), whereas with the lax vowel, as it was more easily transcribed, correlations were non-significant. At word level, correlations demonstrated that listeners' proficiency level correlated well with both vowel types, given that intelligibility at this level was more often hindered as the tokens produced by the BP speakers contained typical phonological processes of transfer from BP regarding consonant production. This brings to attention the role of transfer of phonological processes from BP into English, and the influence these processes pose on intelligibility, as well as the importance of acknowledging listeners' proficiency in intelligibility assessment, as proficiency did corroborate to speech intelligibly at the word level, and for the more difficult vowel at vowel level.

In research question number four, the role of lexical frequency and listeners' familiarity with lexicon were investigated. Results showed that more frequent items were usually more intelligible, and had greater familiarity ratings, thus showing that lexical frequency plays an important role in speech decoding. Research can profit from usage-based approaches (Bybee, 2006) to investigations on intelligibility, as this can elicit how frequency influences intelligibility, as well as how frequency is reflected on the listeners' familiarity with certain lexical items.

Research question number five investigated the relationship of listeners' length of residence and intelligibility, but yielded no fruitful results. That turns attention to controversies with this variable and its relevance to intelligibility. The results obtained in the present study are in tune with the results obtained by Schadech (2013), however, both go against what was found by Cruz (2008). Possibly, more accurate measures of accent familiarity could help understand better the extent to which speaking the L2 with speakers from a specific L1 (for instance, a French speaker communicating frequently in English with Brazilians) could boost intelligibility.

5.2. Pedagogical Implications

The results obtained for research question number one demonstrated that teaching techniques and instruction approaches can profit from the understanding that the high front vowel pair if not distinguished can threat speech intelligibility. Moreover, duration is a salient acoustic cue for L2 speakers of English, and can be incorporated as a teaching technique for the high front vowels, when associated with its differences in production regarding jaw drop and tongue movement/position. Yet, it was found that consonant production, specially the consonants following the high front vowel, does play a major role in intelligibility assessment. Similarly, this feature is present in Jenkin's (2002) LFC, and Cruz's (2012a) model.

Processes of transfer from BP shall as well be addressed in the classroom in favor of speech intelligibility. Vowels were proved not to be segments that solely influence intelligibility, but the entire word. Also, the cotext in which carrier words were inserted also significantly influenced listeners' performance towards intelligibility. Thus, teaching approaches that focus on this dimension can make use of techniques that rely on instruction for more accurate results, as Silveira (2004) argues, the goals of pronunciation instruction rely on the development of learners' intelligibility, communicative ability, self-monitoring and self-correction strategies, and on their ability to understand different speech rates[40]. Besides, Silveira (2004) advocates that "the goals of pronunciation instruction are more likely to be accomplished if we use a variety of language instruction techniques to provide learners with practice that ranges from more controlled to more communicative" (p. 19). Similarly, Foote, Holtby, and Derwing (2011) assert that "pronunciation instruction is unlikely to lead to native-like speech, it can help L2 speakers improve their intelligibility" (p. 04).

In addition, proficiency was demonstrated to notably influence speech intelligibility. Listeners' proficiency shall not be taken for granted as results indicate that listeners with different proficiency levels are able to transcribe certain segments more successfully than others. Although this study has not addressed important issues such as listeners' tolerance to accented-speech or listeners' willingness to make an effort to understand accented-speech, these too constitute the body of variables that influence speech intelligibility (Derwing, 2008; Derwing & Munro, 2009). Derwing (2008) claims that learners' proficiency is one of the factors that teachers and L2 practitioners shall bear in mind, as it can determine the efficacy of pronunciation instruction. The foci of instruction, whether on segmentals or suprasegmentals, are to be determined depending on the performance demonstrated by the learners according to their proficiency level.

[40] Silveira (2004) mentions "ability to understand native speakers' fluent speech", but I believe referring to different speech rates is more accurate. In addition, the scholar points out that instruction can also be fruitful to help learners acquire the L2 phonological system, and deal with L1 interference.

The results obtained with research question number four go in favor with a frequency-based framework for assessing speech intelligibility and teaching. At least, two relevant variables for investigating intelligibility can be looked at within such framework. Lexical frequency and listeners' familiarity, which are highly correlated. Thus, research can only profit from more controlled procedures regarding the choice of the tested lexical items, and listeners' degree with familiarity with them, especially when it comes to the occurrence of these items in classroom-oriented contexts. Also, it is important to bear in mind that lexical frequency has considerable influence on speech decoding, which tends to influence speech intelligibility as well.

5.3. Study limitations and suggestions to warrant further research

Many are the gaps that were not covered in the present study. I shall discuss some of them taking into account the specific research question in which they were observed.

First of all, the number of listeners from each different L1 contemplated in this study is uneven. In order to more accurately understand the reactions of listeners from certain L1 backgrounds when it comes to speech intelligibility, more listeners would be necessary in order for the researcher to have an even number for each L1 background. Another important limitation arises from the fact that the present study did not have BPSE as listeners in the intelligibility test. Thus, the interlanguage speech intelligibility benefit (Bent & Bradlow, 2003), which posits that listeners that share the same L1 of the speakers will show an advantage over other listeners, was not tested. Yet, by having a controlled reading test to gather speech data, the results of this study might not be generalizable to speech in natural settings or to different research approaches on intelligibility. Therefore, more research is needed when it comes to intelligibility as negotiated in extemporaneous speech.

Another relevant suggestion which might help understand L2 speech processing better is to look at how listeners produce the sounds that they will evaluate in an intelligibility task, as "[…] the linguistic backgrounds of both talkers and listeners appear to play important roles in speech intelligibility" (Smith & Harb, 2011, p. 115). Thus, a connection between speech production and speech intelligibility of both listeners and speakers can be bridged by showing how the sounds that listeners evaluate are characterized within their own interlanguage, and how these sounds are recognized when the same listeners are exposed to L2 accented-speech, which will also determine intelligibility. Moreover, research can also profit from investigations on how orthography influences speech decoding and intelligibility measures of different phonological features.

Moreover, two important acoustic cues were not regarded in token selection. F2 was not taken into account when preparing the criteria based on frequencies spectral proximity (only F1 was accounted for), and speech rate, a variable which is to influence intelligibility (Munro & Derwing, 1998) was not observed. Moreover, speech processing time was not measured. This is a variable suggested by Derwing and Munro (2005), as it can reveal degrees of ease or difficulty when processing L2-accented speech.

As regards the research instruments, three are the limitations worth of attention. First, the questionnaire administered to listeners did not seek to investigate use of Portuguese in Brazil. Listeners were required to report on the use of English, but, by being in Brazil, the language they were likely to make use of more often could have been Portuguese. Secondly, a more accurate instrument for measuring proficiency is needed. The experimenter investigated listeners' oral ability when they first encountered, however, there is no doubt that such evaluation was subjective, and thus, a proficiency test that evaluates oral skills would yield more appropriate results and help identify better the listeners' proficiency levels. Third, more research is needed in order that more accurate instruments and procedures are made available. Word transcription is of relevance by being understood as an index of listeners' understanding. However, it does not make possible to state what variable influenced listeners the most. As demonstrated in Section 4.1, it is unclear whether the choice for the word "pig" to complete the utterance "Can you take your…?" was based on a frequent word which was similar to what listeners heard in the stimulus, or based on any differences in the acoustic quality of /k/ that might have influenced perception.

An important suggestion relies on preparing intelligibility tasks with as much acoustic information of the stimuli used as possible. Even when solely testing vowels, the experimenter could also provide acoustic information on the entire carrier word, by analyzing acoustically the preceding and following phonological contexts, for instance. In this case, perception tasks can be used to complement intelligibility tasks, as they can provide valuable information on how listeners perceive certain segments which are not fully developed, or that carry important information transferred from the speaker's L1. In addition, as regards the preparation of sentences to be used in the intelligibility test, cotext priming is an important linguistic variable that can influence the results in intelligibility assessment. Research shall consider such variable in order to provide pertinent insights.

As concerns the scope of future research on intelligibility, researchers shall keep in mind that intelligibility can be investigated at different levels of speech decoding (e.g., vowel, consonant, and word level), as these can provide more accurate insights on the phonological aspects that are likely to influence communication. In addition, specific speech features were proven to act upon speech intelligibility. First, in the case of BP-accented-English, effects of transfer of phonological processes from BP into English shall be broadly and more carefully investigated. Second, in the case of NSE speech, effects of unreleased consonants in final position on intelligibility shall too be explored. Furthermore, it is still controversial whether NSE should take part as listeners in intelligibility studies. Research can come up with answers whether native listeners' judgments are harsher given that they apply norms from their own [native] pronunciation to samples of NNSE, as advocated by Jenkins (2012). Experimental studies shall also compare findings gathered with NL and with NNL in order to observe their influence on intelligibility, given that insufficient empirical evidence has been provided for such claim.

This study has its flaws and it is subject to criticism. Nonetheless, what remains is that much more empirical research is in need to be undertaken in the field so that these flaws can be remediated.

Researchers also need to develop a nuanced view on the many linguistic and non-linguistic variables that influence speech decoding. The query of these researchers is not to answer as many questions as possible, but to ask them from their own personal experience, also seeking to make sense of the answers obtained. As a final point, Munro (2011) deliberates on the needed endeavor towards empirical studies:

> Among applied linguists there is no shortage of ideas about what is and is not important. But bad ideas – especially those motivated by overweening, abstract argumentation rather than practical realities – must not be allowed to trump learners' needs. In particular, we do not need to debate the issue of whether intelligibility is important. Rather, we need to carry on with our work on how we can apply this concept in the most effective ways (Munro, 2011, p. 13).

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APPENDICES

Appendix A – Speakers' profiles

Participant	Age	Gender	Occupation	Place and time abroad
S1	29	Female	Undergraduate student	--
S2	18	Female	Undergraduate student	--
S3	18	Male	Undergraduate student	--
S4	24	Female	MA student	--
S5	23	Male	Undergraduate student	--
S6	24	Female	Public servant	--
S7	28	Female	Biologist	--
S8	18	Female	Undergraduate student	--
S9	18	Male	Undergraduate student	--
S10	20	Male	Undergraduate student	--
S11	25	Male	Public servant	--
S12	33	Female	Public servant	15 days
S13	46	Female	Public school teacher	--
S14	37	Female	Public servant	--

S15	22	Female	Undergraduate student	--
S16	18	Male	Undergraduate student	--
S17	21	Female	Undergraduate student	--
S18	29	Female	Public servant	--
S19	20	Male	Undergraduate student	--
S20	18	Female	Undergraduate student	12 days

Appendix B - Production test

1. Do you always keak?
2. This is a beautiful kitchen set.
3. Can you see the mountain peak?
4. Watch the bat!
5. Give it to Pete.
6. The boy is sad.
7. Take a bet!
8. The doctor sat.
9. Watch out for the pit!
10. Hear the beat.
11. Do not kick!
12. "I love you", she said.
13. Do you like your pet?
14. Can you wait a bit?
15. The food is bad.
16. Give it a pat.
17. Take a seat.
18. It's in your bed.
19. Can you take your pick?
20. And now, can you sit?

Appendix C - Questionnaire for speakers

Universidade Federal de Santa Catarina
Centro de Comunicação e Expressão
Programa de Pós-Graduação em Inglês e Literatura Correspondente
Aluno: Alison Roberto Gonçalves
Professora orientadora: Dra. Rosane Silveira

Questionário

Prezado (a) participante,

Este questionário visa somente obter informações que serão utilizadas para direcionar a análise de dados desta pesquisa. Sob *nenhuma* hipótese, sua identidade será revelada, como também *não* serão divulgadas quaisquer informações que possam identificá-lo. Solicito informar nome e e-mail somente para que, no caso de necessitar alguma informação adicional, eu possa entrar em contato posteriormente.

Parte I – Informações pessoais

1. Nome: ____
____.

2. Idade: _____. 3. Sexo: FEM / MASC 4. E-mail: ___________________________.

5. Turma de Inglês em que está matriculado: _______.

Parte II – Conhecimento de línguas estrangeiras

6. Você fala alguma língua estrangeira? Sim ❑ Não ❑

7. Se você fala alguma língua estrangeira:

a) Qual língua fala? _________________.

b) Com que frequência você fala essa língua?

Frequentemente ❑ Algumas vezes ❑ Raramente ❑

c) Com que frequência você escreve nesta língua (em meio virtual, no contexto acadêmico etc)?

Frequentemente ❑ Algumas vezes ❑ Raramente ❑

8. O quão bem você:

a) Entende essa língua? Muito bem ❑ Bem ❑ Razoavelmente ❑ Não entendo ❑

b) Fala essa língua? Muito bem ❑ Bem ❑ Razoavelmente ❑ Não falo ❑

Parte III – Exposição á Língua Inglesa

9. Você estudou Inglês antes de matricular-se nos Cursos Extracurriculares?

Sim ❑ Não ❑

10. Se sim, onde? (Marque quantas opções desejar)

Pré-escola ❑ Ensino Fundamental ❑ Ensino Médio ❑ Escola particular ❑ Outro ❑

11. Por quanto tempo estudou Inglês?

	1 ano	2 anos	3 anos	4 anos
Pré-escola	❑	❑	❑	❑
Ensino Fundamental	❑	❑	❑	❑
Ensino Médio	❑	❑	❑	❑
Escola Particular ❑	❑	❑	❑	

Outro ❑ ❑ ❑ ❑

Se estudou Inglês por mais de 4 anos, indique o local e o número de anos durante os quais estudou Inglês:

____

________.

12. O que você normalmente estudava?

	Na maioria das aulas	Algumas vezes	Raramente ou nunca
Gramática	❑	❑	❑
Leitura	❑	❑	❑
Escrita	❑	❑	❑
Conversação	❑	❑	❑
Atividades de audição	❑	❑	❑
Pronúncia	❑	❑	❑

13. Com que frequência, você:

	Sempre	Algumas vezes	Raramente ou nunca
a) Ouve músicas em Inglês?	❑	❑	
b) Canta músicas em inglês?	❑	❑	
c) Traduz músicas?	❑	❑	
d) Assiste a filmes em Inglês?	❑	❑	
e) Assiste a programas de TV em inglês?	❑	❑	

f) Estuda Inglês em casa? ❑ ❑

14. Você já esteve em algum país onde Inglês é falado como língua materna?

Sim ❑ Não ❑

a) Se sim, qual país? ______________________.

b) Por quanto tempo você permaneceu neste país?

______________________________.

c) Você frequentou aulas de Inglês enquanto esteve neste país?

Sim ❑ Não ❑

d) Se você frequentou aulas de Inglês fora do Brasil, forneça algumas informações sobre o curso que frequentou (carga horária semanal, habilidades estudadas etc).

____

____

____

15. Se houver, acrescente quaisquer informações que julgar relevantes à pesquisa e que não foram contempladas neste questionário.

____

____

____

Florianópolis,____ de________________ de 2012.

Obrigado por integrar esta pesquisa.
Alison Roberto Gonçalves.

Appendix D - Consent form for speakers

Universidade Federal de Santa Catarina
Centro de Comunição e Expressão
Programa de Pós-Graduação em Inglês e Literatura correspondente
Aluno: Alison Roberto Gonçalves   Nível: Mestrado
Professora Orientadora: Dra. Rosane Silveira

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Você está convidado a participar do projeto de pesquisa “A inteligibilidade das vogais altas anteriores do Inglês produzidas por Brasileiros” que busca estudar características específicas da pronúncia da Língua Inglesa.

Este estudo visa contribuir ao ensino de Língua Inglesa, uma vez que os dados coletados podem servir para a elaboração e melhoria de materiais didáticos, adequando-os às necessidades dos alunos brasileiros aprendizes do idioma e, também, contribuindo para o ensino nas áreas de Fonética e Fonologia de modo geral.

Se aceitar participar da pesquisa, você (i) responderá a um questionário e (ii) lerá algumas sentenças que serão gravadas e integrarão o corpus de análise da pesquisa. Ao ser concluída, esta dissertação será defendida até fevereiro de 2014 e o estudo tornar-se-á público.

Não existem riscos ou desconfortos associados à sua participação. As informações fornecidas e o material coletado serão absolutamente confidenciais e não haverá identificação nominal dos participantes, nem divulgação de quaisquer informações que podem revelar sua identidade.

O participante pode, a qualquer momento, deixar de participar da pesquisa, informando o pesquisador de sua decisão, a fim de que ele não utilize mais os dados do desistente. Além do mais, asseguramos que esta pesquisa está submetida aos critérios da Resolução 196/96 e suas complementares.

A participação nesta pesquisa não acarreta, de forma alguma, em prejuízos ou em privilégios no curso em andamento. Se houver quaisquer dúvidas referentes ao seu desenvolvimento, os pesquisadores estão à disposição para esclarecimentos através dos contatos dispostos abaixo.

Se você estiver de acordo em participar desta pesquisa, assine no espaço abaixo.

Eu, ____,
concordo em participar deste estudo e autorizo o pesquisador a utilizar os dados por mim fornecidos.

____

____

Assinatura do Mestrando **Assinatura da Orientadora**

Florianópolis, ____ / ____/ ______

Appendix E - Questionnaire for NN Listeners

Universidade Federal de Santa Catarina
Graduate Program in English
MA Candidate: Alison Roberto Gonçalves
Advisor: Professor Rosane Silveira

Dear participant,

The present questionnaire seeks to obtain information to be used in the data analysis of this study. Neither your identity nor any piece of information which may reveal your identity are to be published. You are required to inform your name and your e-mail address so as the researcher can get in touch with you if further information is needed.

Full name:

…………………………………………………………………………………

E-mail address: ………………………………………………………….

Part I – Personal Information

01. How old are you?

    ……………………………………………………………………

02. Where were you born?

    …………………………………………………………………

03. Where do you currently live?

    ……………………………………………………………….

04. Where did you live most of your life?

    ……………………………………………………

05. What is your occupation?

……………………………………………………………………..

06. How long have you been in Brazil?

…………………………………………………………

07. Have you lived in other places in Brazil other than Florianópolis? Yes ❑ No ❑

If so, where have you lived?

…………………………………………………………..……

How long did you stay there?

…………………………………………………………………

Part II – Language Knowledge

08. When did you first start to study English?

………………………………………………………

09. Where did you study English?

……………………………………………………………………..

10. Did you ever stop studying English? Yes ❑ No ❑

a) If so, how long were you away?

……………………………………………………………….

11. Have you been to any English-speaking country?

Yes ❑ No ❑

If so,

a. Which country have you been to?

……………………………………………………...

b. How long did you stay there?

………………………………………………………..

c. How old were you when you went there?

……………...

12. How well do you speak English?

Very well ❑ Fairly well ❑ Not well ❑ Not at all ❑

13. How well do you understand English?

Very well ❑ Fairly well ❑ Not well ❑ Not at all ❑

14. Do you speak a foreign language other than English?

Yes ❑ No ❑

a. What language do you speak?

……………...

b. How often do you speak that language?

Frequently ❑ Sometimes ❑ Hardly ever ❑

Part III – Exposure to Brazilian-Portuguese-accented English

14. Do you speak English with Brazilians? Yes ❑ No ❑

a) If so, how often? Frequently ❑ Sometimes ❑

Hardly ever ❑

b) If so, where are these Brazilians you speak English with from?

…………………………………………………………………….....

15. Do you face any difficulties when speaking English with people in Brazil? Yes ❑No ❑

If so, what kind of difficulties?

…………………………………………………………...

16. How well do you understand Brazilian people when they speak English to you?

Very well ❑ Fairly well ❑ Not well ❑ Not at all ❑

17. If there is any other relevant information you may find fitting for this research, please, comment below.

Florianópolis, ____/____/________

Thank you for taking part in this research.

Alison Roberto Gonçalves.

Appendix F – Consent form to listeners

Federal University of Santa Catarina
Graduate Program in English
MA Candidate: Alison Roberto Gonçalves
Advisor: Professor Rosane Silveira

Dear participant,

My name is Alison Roberto Gonçalves and I am an MA student at Federal University of Santa Catarina. I am currently conducting a study on English pronunciation under the supervision of Professor Rosane Silveira and I would like to invite you to take part in our study.

This piece of research seeks to contribute to English teaching in Brazil, given that the data collected might corroborate with the creation and improvement of teaching materials. Yet, it might as well increase the literature available in the field of Phonetics and Phonology by bringing new findings.

If you accept to take part in this study, you will be required (a) to answer a questionnaire, and (b) to listen to some recordings and (c) rate them according to the instructions you receive. Also, (d) you will be given a second form in order to evaluate vocabulary used in the research instruments. This thesis will be concluded and defended by December 2013 and the results will be made public.

There are absolutely no risks or unpleasant situations associated to your participation. Personal information and data gathered will be confidential and your name will not be revealed under any circumstances. If you happen to have any doubts concerning any research issues, just contact me so I can take time to explain them. You can ask questions at anytime

Your participation in this research is entirely voluntary. It is your choice whether to participate or not. Also, you can at any time choose to no longer take part in the study. All you have to do is inform me about your decision so that I can exclude information and the data supplied by you.

I, ____, agree to take part in this research study and I allow the researcher to use the data I will provide.

____
Participant's signature

____

____
MA Candidate signature   Advisor's signature

Florianópolis, ____ / ____/ ______

Appendix G - Intelligibility Test Woksheet

Graduate Program in English
MA Candidate: Alison Roberto Gonçalves
Advisor: Professor Rosane Silveira

You are about to listen to 35 sentences. After listening to each sentence, write down to the best of your ability what you understand.

01) Can you wait a

02) The boy is

03) Can you take your

04) Do you always

05) Give it a

06) The doctor

07) Give it to

08) Take a

09) Watch out for the

10) Take a

11) The food is

12) Give it a

13) Do not

14) And now can you

15) The doctor

16) Hear the

17) Can you see the mountain

18) This is a beautiful kitchen

19) Do you always

20) Take a

21) The boy is

22) It's in your

23) Can you take your

24) Take a

25) The food is

26) Can you wait a

27) Give it a

28) The boy is

29) Can you take your

30) And now can you

31) Can you see the mountain

32) Hear the

33) Do not

34) Take a

35) Hear the

Appendix H - Intelligibility test answer-key

Sentence	Speaker	F1 values of the target vowel	Criteria
01. Can you wait a bit	01	442 Hz	Below 01 SD
02. The boy is sad	05		Distractor
03. Can you take your pick	09	343 Hz	Below 01 SD
04. Do you always keak	14	414 Hz	Above 01 SD
05. Give it a pat	12		Distractor
06. The doctor sat	19		Distractor
07. Give it to Pete	07	451 Hz	Above 01 SD
08. Take a seat	12	372 Hz	Above 01 SD
09. Watch out for the pit	02	419 Hz	Below 01 SD
10. Take a bet	06		Distractor
11. The food is bad	09		Distractor
12. Give it a pat	17		Distractor
13. Do not kick	05	306 Hz	Below 01 SD
14. And now can you sit	11	270 Hz	Below 01 SD
15. The doctor sat	08		Distractor

16. Hear the beat	09	380 Hz	Above 01 SD
17. Can you see the mountain peak	11	310 Hz	Close to the mean
18. This is a beautiful kitchen set	18		Distractor
19. Do you always keak	09	380 Hz	Close to the mean
20. Take a seat	11	311 Hz	Close to the mean
21. The boy is sad	05		Distractor
22. It's in your bed	16		Distractor
23. Can you take your pick	02	472 Hz	Close to the mean
24. Take a bet	14		Distractor
25. The food is bad	09		Distractor
26. Can you wait a bit	14	440 Hz	Close to the mean
27. Give it a pat	12		Distractor
28. The boy is sad	05		Distractor
29. Can you take your pick	09	--	Repeated sentence
30. And now can you sit	Native		Native speaker

31. Can you see the mountain peak	04	468 Hz	Above 01 SD
32. Hear the beat	09	--	Repeated sentence
33. Do not kick	Native	--	Native speaker
34. Take a bet	14		Distractor
35. Hear the beat	Native	--	Native speaker

Appendix I - Familiarity test

Graduate Program in English
MA Candidate: Alison Roberto Gonçalves
Advisor: Professor Rosane Silveira

Rate the words below on a scale from 1 to 3 according to the following:

“0” = I do not know this word;

“1” = “I think I have seen this word before”

“2” = I recognize this word as an English word, but I do not know its meaning”;

“3” = “I know this word”;

Bad

0	1	2	3

Bat

0	1	2	3

Beat

0	1	2	3

Bed

0	1	2	3

Bet

0	1	2	3

Bit

0	1	2	3

Keak

0	1	2	3

Kick

0	1	2	3

Pat

0	1	2	3

Peak

0	1	2	3

Pet

0	1	2	3

Pete

0	1	2	3

Pick

0	1	2	3

Pit

0	1	2	3

Sad

0	1	2	3

Said

0	1	2	3

Sat

0	1	2	3

Seat

0	1	2	3

Set

0	1	2	3

Sit

0	1	2	3

Appendix J - Normality tests for vowel production

Tests of Normality

	Sex	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
		Statistic	df	Sig.	Statistic	df	Sig.
F1Lax	Female	.148	51	.007	.800	51	.000
	Male	.122	31	.200*	.864	31	.001
F2Lax	Female	.098	51	.200*	.976	51	.390
	Male	.098	31	.200*	.912	31	.015
F1Tense	Female	.097	51	.200*	.971	51	.238
	Male	.187	31	.007	.881	31	.002
F2Tense	Female	.078	51	.200*	.981	51	.564
	Male	.187	31	.007	.762	31	.000
DurationLax	Female	.088	51	.200*	.962	51	.100
	Male	.114	31	.200*	.972	31	.570
DurantionTense	Female	.122	51	.058	.970	51	.227
	Male	.131	31	.190	.958	31	.257

Appendix K

Mann-Whitney U for comparison between groups in vowel production

	F1 Lax	F1 Tense	F2 Lax	F2 Tense	Duration Lax	Duration Tense
z	-6.084	-6.182	-7.107	-7.559	-4.161	-3.490
p	.000	.000	.000	.000	.000	.000

Appendix L

Score ranges for placing task-takers

ALTE Level	CEF Level	CEF Level description	Paper and pen test score	
			Part 1 Score out of 40	Parts 1 & 2 Score out of 60
5	C2	Mastery (Upper advanced)		55 - 60
4	C1	Effective proficiency (Lower advanced)	If a student scores 36 or more, it is recommended they complete Part 2 of the test	48 – 54
3	B2	Vantage (Upper intermediate)	31 - 40	40 – 47
2	B1	Threshold (Lower intermediate)	24 - 30	30 – 39

1	A2	Waystage (Elementary)	16 - 23	18 – 29
0.5	A1	Breakthrough	10 - 15	10 – 17
0		(Beginner)	0 - 9	0 - 9

Appendix M

Mean, median, and SD for F1, F2 and duration of the vowels in the current study

	F1 mean	F1 median	F1 SD	F2 mean	F2 median	F2 SD	Duration mean	Duration median	Duration SD
/i/ - female	400	397	45	2579	2566	223	98	95	39
/i/ - male	320	311	46	1909	1932	176	96	100	26
/ɪ/ - female	398	385	82	2442	2451	267	82	81	28
/ɪ/ - male	314	309	40	1942	1958	144	92	94	24

Appendix N

Normality tests for intelligibility data

Tests of Normality

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	df	Sig.
correct_vowel_tense	,134	32	,156	,927	32	,032
correct_vowel_lax	,132	32	,171	,954	32	,185
correct_word_tense	,207	32	,001	,900	32	,006
correct_word_lax	,179	32	,011	,900	32	,006

Appendix O

Script – Plotar vogais

```
#############################################################
# Script para desenhar (plotar) loci das vogais (média e desvio-padrão)
# Script written by Ricardo Bion, November 2006
# Modified by Andreia Rauber, September, 2010
# Modified by Fernando S. Pacheco, Junho, 2012
#
# Entrada:
#   tabela com seguinte formato (gerado pelo script gera_tabela_formantes.praat)
#   c    NOME;    F1(Hz);   F2(Hz);     F3(Hz);
#   onde
#     c: nome do sujeito (não usado nesta versão)
#     NOME; : vogal
#     F1(Hz); e F2(Hz) : usados para a análise (cálculos da média e desvio-padrão)
#     F3(Hz): : não usado nesta versão
# Saída:
#   Gráfico com loci das vogais (média) e indicação do desvio-padrão através de uma elipse
#
# Se ocorrer erro no processamento, verificar:
# 1. Se não há espaço(s) antes ou depois da vogal. É difícil de enxergar na tabela.
# 2. Se há dados suficientes para a análise. O desvio-padrão só é calculado com, pelo menos,
duas medidas.
#
#############################################################
clearinfo
##############################
form PARTICIPANT
comment put 0 for all participants
  integer plot_participant: 0
  integer max_F2: 3200
  integer min_F2: 600
  integer max_F1: 1000
  integer min_F1: 200
  word color_of_the_vowel: Red
  boolean apagar_grafico_anterior 1
endform
##############################

if apagar_grafico_anterior=1
   Erase all
endif

Select outer viewport... 0 8 0 6
Black
Line width... 1
Plain line
Font size... 12
Axes... log10(max_F2) log10(min_F2) log10(max_F1) log10(min_F1)
```

```
One logarithmic mark bottom... 600 yes yes no
One logarithmic mark bottom... 800 yes yes no
One logarithmic mark bottom... 1000 yes yes no
One logarithmic mark bottom... 1500 yes yes no
One logarithmic mark bottom... 2000 yes yes no
One logarithmic mark bottom... 2700 yes yes no
One logarithmic mark bottom... 3200 yes yes no
One logarithmic mark left... 300 yes yes no
One logarithmic mark left... 400 yes yes no
One logarithmic mark left... 500 yes yes no
One logarithmic mark left... 600 yes yes no
One logarithmic mark left... 800 yes yes no
One logarithmic mark left... 1000 yes yes no

Draw inner box

Text left... yes %F_%1 %(%H%e%r%t%z%)
Text bottom... yes %F_%2 %(%H%e%r%t%z%)

#####################################################
select all
tempt = selected("Table")

Copy... temp
Formula... F1(Hz); log10(self)
Formula... F2(Hz); log10(self)
if plot_participant > 0
Extract rows where column (number)... speaker "equal to" 'plot_participant'
endif

color_of_the_vowel$ = "Black"
line_of_the_sd$ = "Dashed line"


table1 = selected("Table")
Collapse rows... NOME; "" "F1(Hz); F2(Hz);" "" ""
nrows = Get number of rows
table2 = selected("Table")

for i from 1 to nrows
  select table2
  label$ = Get value... i NOME;
  for formant from 1 to 2
     f'formant'_em_Hz = Get value... i F'formant'(Hz);
  endfor
  select table1
  Extract rows where column (text)... NOME; "is equal to" 'label$'
  numero_dados = Get number of rows
  if numero_dados < 2
     exit Numero insuficiente de dados para a vogal:  'label$' . Verifique a tabela TXT de
entrada.
  endif
```

```
  for formant from 1 to 2
     sd_F'formant'_em_Hz  = Get standard deviation... F'formant'(Hz);
  endfor
  call plot
endfor
select all
minus tempt
Remove

############
procedure plot
  f1 = f1_em_Hz
  f2 = f2_em_Hz
  stdev_f2 = sd_F2_em_Hz
  stdev_f1 = sd_F1_em_Hz
  'color_of_the_vowel$'
  Text special... 'f2' Centre 'f1' Half Times 24 0 'label$'
  Plain line
  Line width... 1
  x1 = 'f2'-'stdev_f2'
  x2 = 'f2'+'stdev_f2'
  y1 = 'f1'+'stdev_f1'
  y2 = 'f1'-'stdev_f1'
  'line_of_the_sd$'
  Line width... 1
  Draw ellipse... 'x1' 'x2' 'y1' 'y2'
endproc
#########################
```

Appendix P

Script – Plot from table

```
#########################################################
# Script para desenhar (plotar) loci das vogais (cada um dos dados da tabela de entrada)
# Script written by Ricardo Bion, November 2006
# Modified by Fernando S. Pacheco, Junho, 2012
#
# Entrada:
#   tabela com seguinte formato (gerado pelo script gera_tabela_formantes.praat)
#   c    NOME;    F1(Hz);   F2(Hz);     F3(Hz);
#   onde
#     c: nome do sujeito (não usado nesta versão)
#     NOME; : vogal
#     F1(Hz); e F2(Hz) : usados para o gráfico
#     F3(Hz): : não usado nesta versão
# Saída:
#   Gráfico com loci das vogais e indicação do desvio-padrão através de uma elipse
#
# Cores disponíveis: Black, Red, Green, Blue, Yellow, Cyan, Magenta, Marron, Lime, Navy,
Teal, Purple, Olive, Pink, Silver, Grey
#  com inicial maiúscula
#
# Se ocorrer erro no processamento, verificar:
# 1. Se não há espaço(s) antes ou depois da vogal. É difícil de enxergar na tabela.
#
#########################################################

clearinfo

#####################################
form PARTICIPANT
  comment put 0 for all participants
  integer plot_participant: 0
  integer max_F2: 3000
  integer min_F2: 700
  integer max_F1: 1000
  integer min_F1: 200
  word color_of_the_vowel: Blue
  boolean apagar_grafico_anterior 0
endform
#####################################

if apagar_grafico_anterior=1
   Erase all
endif

Select outer viewport... 0 10 0 8
Black
Line width... 1
Plain line
```

```
Font size... 18
Axes... log10(max_F2) log10(min_F2) log10(max_F1) log10(min_F1)

One logarithmic mark bottom... 700 yes yes no
One logarithmic mark bottom... 1000 yes yes no
One logarithmic mark bottom... 1500 yes yes no
One logarithmic mark bottom... 2000 yes yes no
One logarithmic mark bottom... 3000 yes yes no
One logarithmic mark left... 200 yes yes no
One logarithmic mark left... 250 yes yes no
One logarithmic mark left... 300 yes yes no
One logarithmic mark left... 400 yes yes no
One logarithmic mark left... 500 yes yes no
One logarithmic mark left... 600 yes yes no
One logarithmic mark left... 800 yes yes no
One logarithmic mark left... 1000 yes yes no

#One logarithmic mark right... 909 yes yes yes
#One logarithmic mark top... 1100 yes yes yes
#One logarithmic mark right... 273 yes yes yes
#One logarithmic mark top... 2883 yes yes yes

Draw inner box

Text left... yes %F_%1 %(%H%e%r%t%z%)
Text bottom... yes %F_%2 %(%H%e%r%t%z%)

####################################################

select all

tempt = selected("Table")

Copy... temp
Formula... F1(Hz); log10(self)
Formula... F2(Hz); log10(self)


if plot_participant > 0
  Extract rows where column (number)... c "equal to" 'plot_participant'
endif

line_of_the_sd$ = "Plain line"


table1 = selected("Table")
nrows = Get number of rows
table2 = selected("Table")

for i from 1 to nrows
   select table2
   label$ = Get value... i NOME;
```

```
  for formant from 1 to 2
    f'formant'_em_Hz = Get value... i F'formant'(Hz);
  endfor

  select table1
  Extract rows where column (text)... NOME; "is equal to" 'label$'

  numero_dados = Get number of rows
  if numero_dados < 2
    exit Numero insuficiente de dados para a vogal:  'label$' . Verifique a tabela TXT de
entrada.
  endif

  for formant from 1 to 2
    sd_F'formant'_em_Hz  = Get standard deviation... F'formant'(Hz);
  endfor

  call plot

endfor

select all
minus tempt
Remove

procedure plot
 f1 = f1_em_Hz
 f2 = f2_em_Hz
 stdev_f2 = sd_F2_em_Hz
 stdev_f1 = sd_F1_em_Hz

 'color_of_the_vowel$'
 Text special... 'f2' Centre 'f1' Half Times 24 0 'label$'
 Plain line
 Line width... 1

 x1 = 'f2'-'stdev_f2'
 x2 = 'f2'+'stdev_f2'
 y1 = 'f1'+'stdev_f1'
 y2 = 'f1'-'stdev_f1'
endproc
########################
```