FREQUENCY EFFECTS ON THE INTELLIGIBILITY OF ENGLISH WORDS WITH HIGH FRONT VOWELS

EFEITOS DA FREQUÊNCIA NA INTELIGIBILIDADE DE PALAVRAS DO INGLÊS CONTENDO VOGAIS ALTAS ANTERIORES

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Abstract: *The aim of the present study is to examine to what extent intelligibility scores, as measured through word transcription, correlate with lexical frequency and with listeners' familiarity with the target words. 32 listeners from different language backgrounds had to orthographically transcribe ten missing target-words (all CVC words, five with the tense high front vowel and five with its lax counterpart), which were produced by Brazilian Portuguese learners of English. In order to assess word frequency, the Corpus of Contemporary American English (DAVIES, 2013) was used. Moreover, listeners' familiarity with the target lexical items was assessed using a four-point rating scale. Spearman correlations revealed significant, and moderate to strong relationships between intelligibility, frequency and familiarity, showing that the more frequent the lexical item, the more intelligible it was according to listeners' performance; the more familiar listeners were to a certain lexical item, the more intelligible it was. Furthermore, the semantic and syntactic cotext of the sentences containing the target words influenced listeners' performance to a certain extent, depending both on the listeners' L2 proficiency level, the acoustic features of the target words, and lexical frequency.*
Keywords: frequency; Usage-based phonology; intelligibility.

Resumo: *O objetivo do presente estudo é examinar como se relacionam índices de inteligibilidade, medidos através de transcrição de palavras, frequência lexical e familiaridade dos ouvintes com as palavras-alvo. Nesse teste, 32 ouvintes de diferentes línguas maternas tiveram que ortograficamente transcrever as dez palavras-alvo testadas (palavras CVC, cinco com a vogal alta anterior tensa e cinco com a vogal frouxa), que foram produzidas por*

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aprendizes brasileiros de inglês. A familiaridade do item lexical foi avaliada utilizando-se uma escala de quatro pontos. Para avaliar frequência, o Corpus of Contemporary American English (DAVIES, 2013) foi utilizado. Correlações não-paramétricas revelaram relações significativas entre os resultados de inteligibilidade, frequência e familiaridade, demonstrando que quanto mais frequente o item lexical, mais inteligível ele era de acordo com o desempenho dos ouvintes; quanto mais familiar ele era, segundo a avaliação dos ouvintes, mais inteligíveis os resultados do teste eram. Ao se examinar o contexto sintático e semântico das sentenças-veículo nas quais as palavras-alvo apareciam, notou-se que essas informações influenciaram de certa forma o desempenho dos participantes, dependendo do nível de proficiência em L2 dos ouvintes, das características acústicas das palavras-alvo, e da frequência lexical.
Palavras-chave: frequência; Fonologia de Uso; inteligibilidade.

Introduction

For being of relevance for speech assessment and second language (L2) teaching, the current study addresses the notion of intelligibility, that is, how much an utterance is actually understood by a listener (DERWING; MUNRO, 2005). This study aims at investigating the intelligibility of English words containing high front vowels produced by Brazilian speakers, taking into account the likely relationship among measures of vowel intelligibility and variables of lexical nature, namely, frequency and familiarity, which are variables that seek to measure the lexical experience of the listener. The study also considered the role of semantic and syntactic cues provided by carrier sentences, a listener-related factor (L2 proficiency) and the orthography of the target words.

Intelligibility has been proposed as one of the main goals of pronunciation instruction (DERWING; MUNRO, 2005). Kennedy and Trofimovich (2008) have argued that language instructors should be concerned with encouraging learners to pursue intelligible output, as "students whose L2 production is not entirely native-like but who are able to communicate effectively are clearly successful L2 users" (2008, p. 460). As one of the factors that contribute to communication effectiveness, intelligibility has received different definitions (see Cruz, 2007 for a detailed discussion). Catford (1950) and Smith and Nelson (1985) define it as the hearer's understanding of the speaker's words (or utterances), placing the focus on the ability of decoding words. Smith and Rafikizad (1979) present a similar

definition, but they specify that intelligibility involves the capacity to understand word(s) spoken/read in the context of a sentence. Conversely, Jenkins (2000) defines intelligibility as the production and recognition of formal properties of words and utterances, especially at the phonological level. Jenkins' definition makes it clear that intelligibility depends on the performance of both speakers and listeners, given that the research method proposed by the researcher requires face-to-face interactions and examines what causes communication breakdowns, with a focus on the speaker's mispronunciations.

Derwing and Munro (2008) present another definition that is frequently adopted by researchers. These authors regard intelligibility as "the degree of a listener's actual comprehension of an utterance" (2008, p. 479). We favor this definition because it leaves open the possibility of focusing on either listener's performance, speaker's performance, or the utterances themselves (or maybe the three of them). Moreover, the body of research conducted by these authors 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).

Turning to the notion of frequency, usage-based researchers have argued that by looking at features, words, or constructions[3] that are repeated in language, more of language granularity and its organization is unveiled. Cognitively oriented research has also shown that mechanisms of human cognition are affected and even shaped according to particularities of the linguistic activity. For instance, learning, be it unconscious and naturalistic or conscious and instructed, is believed to arise from learners' experience with particular conventions (BYEBEE; HOPPER, 2001; BYBEE, 2010; ELLIS, 2011). In general lines, what is experienced more frequently is learned more easily and is generally readily available in the mind of the user. Ellis (2012) claims that "learning, memory and perception are all affected by frequency of usage: the more times we experience something, the stronger our memory for it, and the more fluently it is accessed" (ELLIS, 2012, p. 4). When discussing her view of language acquisition, Kuhl (2000) points out three major guides:

> First, infants detect patterns in language input. Second, infants exploit the statistical properties of the input, enabling them to

3 Constructions are chunks of language, combinations of words that carry lexical, pragmatic, semantic and phonological characteristics (BYBEE; HOPPER, 2001).

> detect and use distributional and probabilistic information […]. Third, infant perception is altered—literally warped—by experience to enhance language perception. (KUHL, 2000, p. 11852)

Kuhl (2000) calls attention to the importance of regularity in the linguistic input from which distributional properties will be perceived and hence make it possible for the infant to "decide" what needs to be represented. From regularity, it is clear that the linguistic property needs to be present within repeated frequency (i.e., it must occur a number of times). It is apparent that learning mechanisms in early infancy revolve around these statistical properties, whereas bearing major effects to our cognition – as in the case of Kuhl's excerpt, perception.

As regards the effects that frequency impinges on cognition, most of the available evidence comes from Psycholinguistics and usage-based oriented research (ELLIS, 2011). Processing has been demonstrated to be sensitive to frequency in all levels of language representation, and it is not surprising that models in language perception, auditory and visual word recognition and syntactic processing include at least one section dedicated to effects of frequency. Moreover, Ellis (2011) discusses that frequency effects "are thus compelling evidence for usage-based models of language acquisition which emphasize the role of input" (ELLIS, 2011, p. 13), for entailing that individuals must have registered occurrence in processing somehow.

When it comes to its genesis, lexical frequency was first studied by John Carroll around 1939, when preparing a paper that focused on pronoun use by children (LEVELT, 2013). With the development of Information Theory with the goal "of studying the efficiency of the communicative process" (LEVELT, 2013, p. 6), word frequency was again scrutinized for it was believed that by observing the probabilities of the lexicon, the speaker's next turn would be better predicted. Later on, Howes and Solomon (1951, as cited in Levelt, 2013) found that more frequent words were more easily recognized in the tachistoscope. Such a finding was of major significance given that most psycholinguistic models have incorporated the notion of frequency. George Kingsley Zipf (1902–1950), the author of the Zipf's law, accomplished another important discovery motivated by frequency in psycholinguistics. According to the Zipfian distribution, the most frequent word occurs twice as often as the second most frequent word, three times as often as the third most frequent word etc. Levelt (2013) claims that these statistics become more interesting when context is taken into account, "as a speech sound or word […] can be more or less redundant dependent on its preceding context" (LEVELT, 2013, p. 14).

Current models of language processing have included the mechanism of frequency in their operations. In spoken word recognition, Dahan and Magnuson (2006) posited that word frequency directly affects the activation of words in the aural input according to models from the localist view[4]. As noted by the authors, words accumulate activation proportionally to their match with the incoming signal, thus, words more frequently heard are readily available and are more easily activated. In visual word recognition, Rastle (2007) discusses that one's experience with words is somehow encoded in local orthographic representations of known words and thus influences the ease with which those words are recognized. Van Gompel (2006), in his discussion on sentence processing, claims that verb frequency information affects the resolution of syntactic ambiguity. As an example to illustrate such a case, double-object verbs are rare in Brazilian Portuguese, thus this could be one of the reasons why students show some preference for prepositional verbs when learning English ("She gave the book to Anna" instead of "She gave Anna the book") (SALLES; SCHERRE, 2003; TORRES-MORAIS; BERLINCK, 2006).

From our discussion in the previous paragraphs, it is clear that intelligibility is a complex speech measure that involves a great myriad of intervening variables, including lexical frequency. Two studies have heretofore drawn considerations on intelligibility and frequency while examining data from Brazilian learners of English: Becker (2013) and Schadech (2013). These studies are outlined and their findings regarding frequency are discussed below.

Becker (2013) developed a study on intelligibility having Brazilians as listeners. The researcher collected samples of different types of accented English from the *Speech Accent Archive* (WEINBERGER, 2013), and presented them to *Letras* undergraduate students. The stimuli used by the researcher (a paragraph read by each speaker) 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 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

4 Embick (2010) explains that in the localist view "the relation between abstract underlying representations is characterized by a series of local changes, each of which typically involves a single target in an environment that is locally determined" (2010, p. 02). An underlying representation, according to the author, consists of morphemes that are grouped into words and phrases by the syntax.

their point of view, hindered intelligibility. The researcher analyzed her intelligibility results according to frequency as measured in two corpora (BNC and COCA). However, given the great number of words which were analyzed and their variability in both of the frequency ranks, it was difficult to draw considerations regarding the role of frequency in the tasks developed by the author. For instance, "also", which was ranked 81st and 87th according to the BNC and COCA, respectively, was one of the most intelligible words in the study (more than 90% of intelligibility). However, "can", which was ranked 37th in both corpora, thus being a more frequent word than "also", had a worse intelligibility level, around 60%. This sheds light on the complex interactions of variables that might have influenced her results more than frequency.

Schadech (2013) investigated the production of word-initial /ɹ/ by Brazilians and the issues of intelligibility and comprehensibility. The stimuli consisted of tokens of Brazilians' productions of sentences that could make sense if they contained minimal pairs such as 'head' [hɛd] or 'red' [rɛd]. The researcher had seventy-three listeners divided into three groups: (1) native speakers of English; (2) advanced Brazilian speakers of English, mostly MA and PhD students; and, (3) students enrolled at an advanced level from an English extension course. 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. The investigator observed the role of lexical frequency by showing that the most frequent items (e.g., "habits"), as measured in COCA, were considerably more intelligible than the less frequent counterparts ("rabbits").

As the results of these two previous studies suggest, language development is a complex system (LARSEN-FREEMAN; CAMERON, 2012), and we expect that multiple variables may somewhat influence intelligibility. In this paper, we look beyond the lexical frequency level and discuss the role played by semantic and syntactic cues present in the test sentences containing the target words. Throughout the analysis, we use the term 'cotext' to refer to the items that accompany the target words used in the intelligibility test. With regard to cotext, Derwing and Munro (2005) state that it is an important variable in intelligibility assessment. In the data analyzed here, all the sentences containing the target words that should be transcribed were presented in the test worksheet, so that listeners would have this information available when taking the test (GONÇALVES, 2014). Moreover, all the sentences used were meaningful so that unintelligibility was not facilitated. However, one of the drawbacks in having presented the cotext is the triggering effect it may bear for certain

words, which could be predicted just by looking at the sentences. This possibility is explained by the fact that "language users tend to produce the most probable utterance for a given meaning on the basis of frequencies of utterance representations" (ELLIS, 2002, p. 145). For instance, the word "beat" is likely to occur in a cotext such as "can you hear the…?" and would be easily predicted by listeners if they were asked to complete the sentence without the aural aid as speakers have memory of constructions that are available in the language. This variable has been regarded in studies in which the target words were embedded in semantically predictable and unpredictable cotexts (KENNEDY; TROFIMOVICH, 2008).

Another variable that may impact the intelligibility test results is orthography. When it comes to orthographic influences, research has demonstrated that phonological representations are altered as a consequence of experience with the printed form of words. Studies have reported that when processing speech, both phonological and orthographic forms are used to map the phonetic forms available in the incoming signal, therefore allowing for orthographic influence on both speech perception and production (RASTLE *et al.*, 2011; ZIEGLER *et al.*, 2008). In the case of non-native word learning, the effect of orthography might be more robust when it is opaque, that is, when there are few grapheme-to-phoneme correspondences in the L2. Escudero *et al.* (2014) have argued that "listeners with a transparent native orthography tend to be misled when the [L2] orthography does not match the phonology in a straightforward way" (p. 385).

Finally, this study examines the performance of listeners from different L1 backgrounds. Although no attempt was made to control for this variable, we are aware that the listeners' native language background may affect their performance. At this point we deem important to at least account for the status of the contrast between tense and lax high front vowels in the phonological inventories of both the speakers' and the listeners' L1s. In BP, the first language of the speakers in this study, the vocalic inventory consists of seven monophthongs in stressed position ([i, e, ɛ, a, o, ɔ, u]) (CRISTÓFARO-SILVA, 2012), but there is no lax high front vowel. A similar situation is found for seven of the listeners' L1: Spanish (BRADLOW, 1995), Danish (KIVISTÖ-DE SOUZA; CARLET, 2014), French (TRANEL, 2000), Finnish (SUOMI; TOIVANEN; YLITALO, 2008), Italian (LOPORCARO, 2005), Polish (CHOCIEJ, 2009), and Russian (BARNES, 2007). Conversely, three of the listeners' L1 possess the tense/lax contrast for high front vowels: Arabic (KOPCZYNSKI; MELIANI, 1993), Dutch (COLLINS; MEES, 2003), and German (WILKINSON, 2005). Thus, we expect the contrast between tense and lax vowels to pose difficulty to most listeners.

In this section, we discussed the theoretical framework guiding this study and the variables that might account for our results regarding words containing English high front vowels. We shall now move on to the reanalysis of the data from Gonçalves (2014) in order to discuss the relationship between intelligibility, frequency and familiarity, while addressing possible influences of sentence-related factors, listeners' proficiency, and target word orthography. Detailed information about the study design and data analysis is provided in the next section.

Method of the present study

Now we begin to examine the role of word frequency and familiarity in the intelligibility of words containing English lax and tense high front vowels. To accomplish such a goal, we revisit data from Gonçalves (2014)[5]. The findings are discussed within the theoretical framework presented in the previous sections and possible intervening variables that may help us understand our results, namely, semantic, syntactic and acoustic cues, listener's proficiency level, and target word orthography are also examined. The following research question and hypothesis guided our analysis:

RQ1: *How do frequency and lexical familiarity correlate with a measure of word intelligibility*?
H1: *Frequency, familiarity and intelligibility are all correlated*.

In addition to answering this central research question, we examine how (a) semantic and syntactic information provided by the carrier sentences used in the intelligibility test, (b) listeners' proficiency, (c) and target word orthography may have influenced the intelligibility test results.

Talkers and acoustic data

Speech data were initially provided by 20 native speakers of Brazilian Portuguese (13 women and 7 men), all of whom were recruited for being readily available for participation. The participants were receiving 3 hours

5 Gonçalves' (2014) project was reviewed and approved of by the Ethics Research Board from Universidade Federal de Santa Catarina (UFSC), under the register 242.979 (April 2013). It integrated the project *Características da interfonologia e suas implicações para a inteligibilidade e o ensino de línguas.*

per week of English instruction in a classroom context. From this initial pool of speakers, we selected tokens from nine Brazilians to include in the Intelligibility Test. The women's ages ranged from 18 to 33 (*M*: 25.6), and the men's ages ranged from 23 to 25 (*M*: 24). They all volunteered to take part in the study. The data set also includes one token produced by a native speaker of English, a 20-year-old male from Albany (NY), who kindly agreed to participate.

Speech data were supplied through a sentence-reading test. The speakers were required to read aloud twenty sentences containing the target words, along with distractors. Figure 1 demonstrates the controlled phonological environment along with the tested words[6]. These lexical items were selected, given that the central objective of Gonçalves' (2014) study was to test the intelligibility of English high front vowels[7].

b_t	beat	bit
k_k	keak	kick
p_k	peak	pick
p_t	Pete	pit
s_t	seat	sit

Fig. 1 – Tested words. Source: Gonçalves (2014)

English lax and tense vowels produced by the Brazilian speakers contained F1, F2 and duration values that differed from the average values the literature proposes for monolingual speakers of English. Figure 2 reports the acoustic data for the entire sample (N=20) of BP speakers who participated in this study (GONÇALVES, 2014) and the values for L1 English (RAUBER, 2006; N= 18). The fact that the BP speakers' values for both lax and tense vowels are noticeably similar shows that they had difficulties producing a distinction between these vowels, and this was expected to hinder listeners' performance on the intelligibility test.

6 The phonological context needs to be controlled because consonants surrounding the vowels affect their quality, especially 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").

7 Yavas (2011) posits that a binary grouping in American English vowels involves the distinction of tense and lax vowels. English has minimal pairs such as "seat" and "sit", 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 Brazilian Portuguese, tense/lax is not a distinctive feature used to characterize vowels (CRISTÓFARO-SILVA, 2012).

	F1				F2				Duration			
	[i]	SD	[ɪ]	SD	[i]	SD	[ɪ]	SD	[i]	SD	[ɪ]	SD
L1 English-male[a]	280	22	412	43	2331	152	1884	172	140	24	118	20
L1 English-female[a]	308	35	501	55	2766	117	2121	95	130	28	103	22
BP speaker-male[b]	320	45	314	40	1909	176	1942	144	96	26	99	24
BP speaker-female[b]	400	46	398	82	2579	223	2442	267	98	39	82	26

[a] Values reported by Rauber (2006).

[b] Values reported by Gonçalves (2014)

Fig. 2 Acoustic values for lax and tense vowels in English as an L1 and in the BP speakers' data

Listeners

Listeners were 32 speakers of English from the following language backgrounds: one Arabic, one Danish, two Dutch, one Dutch-French, one Finnish, two French, three German, one Italian, one Polish, two Russian, seventeen Spanish. All listeners were recruited through informal advertising and social networking. None of them were paid to participate. Gonçalves (2014) investigated if participants were able to sufficiently communicate in English through an informal face-to-face interview, as having sufficient fluency was a requirement to take part in the experiments. No participant reported being hearing impaired. Listeners were 18 men and 14 women, whose length of residence in Brazil ranged from two 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). Their proficiency in English was measured through the Oxford Proficiency Test (ALLAN, 2004), and the results revealed that listeners' proficiency levels were elementary (5), lower-intermediate (11), upper-intermediate (7), lower-advanced (5), and upper-advanced (4).

From the pool of listeners, 21 had visited a number of English-speaking places (Canada, England, Hong Kong, India, Ireland, Jamaica, New Zealand, the USA, Netherlands, Scotland, Singapore), and four reported that they had lived in English-speaking places (from one to 20 years, in places such as Canada, Hong Kong, Ireland, and the USA). Most listeners acknowledged learning English at schooling environments (such as language schools, and at the university), and naturalistically by visiting places where English is spoken. When it comes to domain-based use of English, all of them reported that they were used to speaking English with Brazilians in personal affairs, and for some of them, English was the sole language used for communication in Brazil.

Intelligibility test

The intelligibility test included nine utterances produced by the Brazilian speakers who completed the sentence-reading test and one utterance produced by the native speaker of English. The ten sentences containing the target words were mixed with ten distractor-sentences (e.g. "'I love you', she said"; "Do you like your pet?") not to bias the listeners into predicting the target sounds. Listeners were asked to orthographically transcribe the missing words in the sentences included in the intelligibility test, after listening to each sentence once[8], as this is a common procedure in studies assessing intelligibility (MUNRO, 2008). In order to prevent listeners from misinterpreting the stimuli, which would lead them to create new sentences and put at risk the use of the tested target words, listeners were required to transcribe only the final word in the excerpts.

Frequency data

The Corpus of Contemporary American English (COCA) was used to test for lexical frequency. This corpus consists of 450 million words assembled from texts of a wide range of genres: spoken language, fiction, popular magazines, newspapers, and academic journals (DAVIES, 2009). Therefore, it was expected that the participants' experience with language was somehow reflected in the corpora assembled by COCA. Figure 3 displays word frequency of the ten tested words according to COCA, and presents them in a rank of frequency (RoF), developed to establish the frequency of the words utilized in the present study. As can be seen, the stimuli included both highly frequent words such as the pairs 'beat'/'bit' and 'seat'/'sit', as well as low-frequency items such as 'keak' and 'pit'.

	Frequency in COCA	RoF		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

Fig. 3 - Frequency of the tested words according to COCA. Source: Gonçalves (2014)

8 Intelligibility was considered the first impression (CRUZ, 2004).

Word-familiarity test

Based on the prediction that the frequency of the tested words might not directly reflect the experience listeners have had with them, Gonçalves (2014) employed a word-familiarity test (BENT; BRADLOW, 2003) to check how familiar listeners were with the tested words. The test encompassed a Likert scale presenting 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".

Bit

0	1	2	3

The listeners received a worksheet (see example above) where the familiarity scale was inserted on the top of the page, and they were required to rate each word presented in the intelligibility test. The word-familiarity test included all words used in the intelligibility test stimuli, but only the ten target words reported in Figure 1 were analyzed.

Procedures and data analysis

Each listener was tested individually at a language lab. The instruments were administered in a row, following the sequence demonstrated in Figure 4:

Instruments	Task Duration
Consent form	4-5 minutes
Proficiency test	30-40 minutes
Intelligibility test	10 minutes
Word-familiarity test	5 minutes
Questionnaire	10 minutes

Fig. 4 – Instruments administered and mean time each participant took. Source: Gonçalves (2014).

All the stimuli were played on BS Player, using a Toshiba Satellite C655 computer, along with a Microsoft headset LifeChat LX-3000. In each listening session, the researcher in charge of data collection 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.

Intelligibility was operationalized as the frequency of correct orthographic transcription for the ten tested words. Gonçalves (2014) considered a transcription correct if all the letters were present and in the correct order (BRADLOW; PISONI, 1999). Misspelling that would lead to homophonous words also counted as a correct transcription, thus, if the graphemes "ee" appeared to replace "ea" (in 'beat', for instance), this transcription would also be considered correct for they are homophones. Data were computed in SPSS (version 17). The statistical procedures encompassed the observation of descriptive statistics, the conduction of normality tests and, lastly, running correlations for these three variables: intelligibility, frequency, and familiarity. For the additional intervening variable, given the exploratory nature of the analyses, no statistical tests were run and the results are displayed in terms of raw frequencies and/or percentages.

Results and discussion

This section reports the results for the central research question and the exploratory analysis of possible intervening variables.

Relationships between lexical frequency, lexical familiarity and intelligibility

The central hypothesis guiding this study posed that lexical frequency ranks, lexical familiarity rates, and intelligibility test scores would be correlated. Correlations indicate how strongly one variable can predict the other (LARSON-HALL, 2010). Figure 5 displays the tested words according to their rank of frequency (RoF) in the COCA corpus (the higher the number, the more frequent the word is), listeners' lexical familiarity rates, and intelligibility scores.

	Frequency in COCA	Familiarity rate means	Intelligibility scores
bit	83,131	3	78.1%
sit	45,762	3	75%
pick	42,739	3	28.1%
beat	40,572	3	56.2%
seat	35,594	3	53.2%

peak	12,597	3	53.1%
kick	12,050	3	87.5%
Pete	11,318	3	3.1%
pit	6,782	2.5	0
keak	4	0	0

Fig. 5 - Frequency rank, familiarity rates, and intelligibility scores of the tested words. Source: Gonçalves (2014)[9]

As this analysis includes two ordinal variables in non-normal distribution, 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 similar variables. The output revealed that the correlation between word familiarity and word frequency is strong (*rho* = .701), and significant (p = .024). Indeed, 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. Yet, 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 suggests that lexical familiarity might not be accurately measured on a four-point scale, or that the frequency measure used fails to capture the lexical knowledge of L2 users accurately. As most of the words tested were highly frequent, this led listeners to assign 3 to many of the lexical items, making most words fall into the same category (very familiar items), even if these words had a lower frequency rank in the COCA corpus. Word frequency was overall positively correlated with familiarity. Nonetheless, only items with notably lower frequency ('pit' and 'keak') received low rates regarding familiarity. (*M = 2.5,* and *0*, respectively).

Familiarity also correlated to intelligibility, as Spearman indicated a moderate to strong (*rho* = .696), and significant (p = .025) relationship. Word familiarity appears to be a good predictor of listeners' performance on the intelligibility test. From the ten tested words, five that were assigned the maximum rate on the familiarity rating scale tended to have the higher percentages of correct transcriptions in the intelligibility test, for all of them

9 The intelligibility test percentages reported by Gonçalves (2014) are slightly different because the author repeated five of the ten sentences with the target words, aiming at assessing listeners' reliability. Here, these repeated tokens are not analyzed.

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.

Concerning the correlation between lexical frequency and intelligibility, the Spearman coefficient was moderate (*rho* = .652), and significant ($p = .041$). The word with the highest intelligibility score was 'kick' (almost 90%), which was the seventh in the frequency rank (but ranked high in the familiarity test). 'Bit' and 'sit' were the second and third most intelligible words, considering how well recognized they were (78.1% and 75%, respectively), and these words were the two most frequent ones. The relationship between frequency and intelligibility is clearer when it comes to low-frequency items such as the case of 'Pete', 'pit', and 'keak' (the last two were also less familiar to the listeners). These items obtained, respectively, 3.1%, 0% and 0% of correct responses in the intelligibility test. 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 explain why words containing the lax vowel yielded the highest percentages of correct transcriptions in the intelligibility test. As for the case of 'kick', we also believe that having a counterpart that was not known by most listeners might have influenced this word to have higher intelligibility rates.

As concerns the theoretical framework guiding this study, token frequency (measured both on the COCA corpus and through a word-familiarity task) were shown to be associated with decoding words in the intelligibility measure. More frequent items are believed to be represented in the listeners' lexicon, stressing the lasting effect that frequency has on the formation of linguistic categories in the learners' cognition.

As concerns some intervening variables, we examine in this study how sentence cotext may have influenced listeners' performance on the intelligibility test, reporting the words that were more frequent in the listeners' transcriptions for each sentence in the intelligibility test and the rate of correct responses. We list below the sentences used in the intelligibility test, and the numbers that appear in front of the sentences refer to their order of presentation in the original intelligibility test designed by Gonçalves (2014) and are also used throughout the discussion to make it easier to refer to each sentence.

4 - Do you always keak?
7 - Give it to Pete.
9 - Watch out for the pit!
13 - Do not kick!
16 - Hear the beat.
20 - Take a seat.
23 - Can you take your pick?
26 - Can you wait a bit?
30 - And now, can you sit?
31 - Can you see the mountain peak?

In our view, sentences 16, 23, 26 and 31 provided some level of semantic cue due to the verb or noun preceding the target word. In these cases, both the preceding verb (and noun, in the case of sentence 31) and the target word are frequently used together. Indeed, frequency results obtained by searching for the word combinations on Google yielded the following results: 344,000 hits for "hear the beat" (sentence 16); 10,300,000 for "take your pick" (sentence 23); 39,900,000 for "wait a bit" (sentence 26); 464,000 for "see the mountain peak" and 783,000 for "mountain peak" (sentence 31). Moreover, syntactic cue is provided in the sense that three sentences requested a verb as a response (4, 13, 30), sentence 7 asked for a noun or a pronoun, and the remaining sentences triggered a noun. Syntax is relevant because in some cases, the words that had to be understood by the listeners were minimal pairs such as 'seat' (noun, sentence 20) and 'sit' (verb, sentence 30), and the proper use of syntactic information might have helped the listener to transcribe the target words.

Data displayed in Figure 6 allow us to examine the type of answers provided by the listeners and the possible influence of semantic and syntactic cues provided by the carrier sentences. As previously reported, the highest percentages of correct responses were obtained for sentences (13) (87.5%), (26) (78.2%), and (30) (75%). Interestingly, among these sentences, only sentence (26) provided both semantic and syntactic cues to help the listeners to transcribe the target words. Three of the four sentences that provided both semantic and syntactic cues yielded over 50% of correct responses, but one of them (sentence 23) yielded a mere 28.1% of correct responses. It is possible that for (23), the listeners found it difficult to understand the word produced by the speaker, which led them to provide twelve different types of answer (the majority were nouns, as cued by the sentence syntax). Many of these responses included words beginning with different conso-

nants than that expected for the target word ('pick' or 'pic'). These results clearly indicate that the semantic cue was not sufficient to help the listeners overcome difficulties posed by the acoustic signal, as produced by the BP speaker, which involved the non-target production of the lax vowel, but also the quality of the consonant onset [p], which BP speakers often fail to aspirate.

Sentences	**4**	**7**	**9**	**13**	**16**	**20**	**23**	**26**	**30**	**31**
Cotext cue[a]	Verb	*Noun or pronoun*	*Noun*	*Verb*	*Noun* -beat	*Noun*	*Noun* -pick, pic, peak	*Noun* - bit	*Verb*	*Noun* - peak
Target	keak	Pete	pit	kick	beat	seat	pick	bit	sit	Peak
Correct responses	0%	3.1%	0%	87.5%	56.2%	53.1%	28.1%	78.1%	75%	53.1%
Most frequent responses	pick (11) 35.5%	peach (12) 37.5%	beach (8) 25%	kick (28) 87.5%	beat (18) 56.2%	seat (17) 53.1%	pick (9) 28.1%	bit (25) 78.1%	sit (24) 75%	peak (17) 53.1%
Other Responses	kick (9)	each (5)	each (5)	keep (3)	bit (8)	sit (15)	peak (5)	beat (5)	seat (3)	pick (10)
	click (5)	pitch (4)	beat (3)	quit	bird (2)		kick (3)	bed	set (3)	pick (3)
	kit	beach (3)	heat (3)		pit		pig (3)	base	said (2)	Eak
	speak	bitch (3)	? (2)		bet		seat (2)			Pig
	pig	peadt	pitch (2)		beard		ink			
	peak	bach	it (2)		beet		quick			
	keep	me	bitch				peadt			
	peek	Pete	eat				?			
	peack	pit	peach				egg			
			bridge				bic			
			beaches				feet			
			bit							
			wich							

[a] Cotextual cue was provided by the sentence syntax and, in the case of sentences 16, 23, 26, and 31, also by semantic information carried by the verb and/or noun preceding the target word

Fig. 6 – Responses provided by listeners for each carrier sentence

The sentences with the lowest rates of correct responses were (4), (9), and (7), all of which provided syntactic cues only. These sentences also differ from the others because they contained the words with the lowest

lexical frequency rank in COCA, in addition to a proper name (sentence 7). These factors, added to the lack of semantic cues in the carrier sentence, may have contributed to the low intelligibility scores. An alternative explanation is possible for the target words in sentences (7) and (9). For sentence (7), whose target word was 'Pete', most listeners provided responses containing nouns and pronouns, as prompted by the sentence syntax. However, most of the responses show that the listeners heard a word with the tense vowel and ending in an affricate consonant. This last result indicates that the speaker produced the final consonant /t/ with an affricate quality ('peach' was the listeners' most frequent response), which probably explains why listeners had difficulty transcribing the target word, a quite common proper name in English. The difficulty caused by the transfer of L1 phonetic features into the L2 production of coda consonants was also observed for sentence 9, whose target word was 'pit', which no listener succeeded in transcribing correctly, but once again, most responses were nouns (as required by the sentence syntax) ending in an affricate consonant, such as 'beach' (the most frequent response).

Sentence (20) is an interesting case to examine if we want to gain insights into how the listeners utilized syntactic cues to transcribe the target words. Syntactically, this sentence required a noun in the response, but no explicit semantic cue was provided. The target word was 'seat', but the results clearly show that the listeners struggled to transcribe this token, since 53,1% answered with the target word, but 46,8% answered with the verb 'sit', thus violating the sentence syntax. Here it is clear that the syntactic cue alone was insufficient to help listeners to disambiguate between the minimal pair 'seat' and 'sit', given the acoustic nature of the vowel produced by the speaker. Indeed, very often the listeners struggled between minimal pairs containing the long and tense vowels, as shown by the results of sentence (16) ('beat' and 'bit'), (31) ('peak' and 'pick'), and (20) ('seat' and 'sit'), even when a semantic cue was present in the carrier sentence. Thus, we can argue that when acoustic information is conflicting, listeners may struggle to understand English words containing tense and lax vowels as they are produced by BP speakers, and this difficulty remains when highly frequent words are being transcribed, despite the availability of syntactic and/or semantic cues. Moreover, the fact that even the sentence provided by the native speaker of English (30), which did not provide semantic cue but had the target word pronounced in a target-like fashion, did not lead to 100% of correct responses indicates that indeed some of the listeners might have difficulty distinguishing between the lax and tense vowels.

The data collected by Gonçalves (2014) allow us to examine the extent to which the cotextual cues may have interacted with listeners' proficiency and lexical item orthography, thus influencing the intelligibility test results. In Gonçalves (2014), proficiency was an intervening factor when considering the listeners' performance on the intelligibility test. The results displayed in Figure 7 show the percentages of correct responses among the most proficient listeners (i.e., the 16 listeners who were classified as upper intermediate, lower or upper advanced in the proficiency test) and the least proficient ones (i.e., the 16 listeners classified as elementary or low-intermediate). As we can see, the more proficient listeners obtained the highest percentages of correct responses for all sentences, except for sentences (4) and (9), which were equally difficult for more and less proficient listeners. For most sentences, both groups of listeners present similar ranks of correct responses, which shows that the availability of cotextual cues benefitted both more and less proficient listeners in a similar way. Although the three sentences with the lowest percentages of correct responses for the two groups provide syntactic cues only, they were probably difficult to transcribe because of the low lexical frequency level of the target words and the acoustic quality of the target word produced by the BP speaker. In addition, even the most proficient speakers were faced with great difficulty when transcribing these words.

Sentence	Contextual cues	Total percentage of correct responses (N=20)	% of correct responses – more proficient listeners (N=16)	% of correct responses - less proficient listeners (N=16)
13	syntactic	28 (87.5%)	16 (100%)	12 (75%)
26	semantic + syntactic	25 (78.1%)	16 (100%)	9 (56.2%)
30*	syntactic	24 (75%)	15 (93.7%)	9 (56.2%)
31	semantic + syntactic	17 (53.1%)	14 (87.5%)	3 (18.7%)
16	semantic + syntactic	18 (56.2%)	12 (75%)	6 (37.5%)
20	syntactic	17 (53.1%)	11 (68.7%)	6 (37.5%)
23	semantic + syntactic	9 (28.1%)	5 (31.2)	4 (25%)
7	syntactic + semantic	1 (3.1%)	1 (6.2%)	0 (0%)
4	syntactic	0%	0 (0%)	0 (0%)
9	syntactic	0%	0 (0%)	0 (0%)

*Sentence 30 was provided by a native speaker of American English.

Fig. 7 - Results for sixteen listeners with higher proficiency level (upper intermediate, low advanced and upper advanced).

In the case of Brazilian Portuguese, some investigators have made a strong case for the influence of L1 orthography on L2 English (ALVES, 2005; SILVEIRA, 2007; 2009; 2012), as the BP spelling and sound relation is much more transparent than in English. Brazilian Portuguese has only one high front vowel [i], which has different spectral frequencies and duration[10] values than the English tense and lax high front vowels. In terms of spelling, in Portuguese, [i], in stressed position, is always spelled with <i>. However, English has much more complicated spelling rules for the lax and tense high vowels, which often pose a challenge to Brazilian and certainly to speakers of other languages with transparent spelling, such as Spanish, the L1 of about 55% of the listeners in this study. Note that 50% of the target words used in the intelligibility test had the lax vowel, all spelled with the regular spelling in English <i>, and the other 50% had the tense vowels (four spelled <ea> and one <e>). As the three target words with the highest rates of correct responses are spelled with the most consistent spelling <i>, one may wonder whether the listeners' transcriptions may have been influenced by the more transparent spelling-sound rules of the lax vowel. As observed by Alves (personal communication), taking into account the target words used in this study, it is possible to see that the spelling pattern for the lax vowel is simpler than that used for the tense vowel. In this sense, listeners, not knowing how to distinguish between the lax and the tense high vowels (which, as shown in Fig. 2, were produced with similar spectral values by the nine BP speakers), tended to go for the simplest spelling. Thus, if the stimulus they heard was difficult to understand, given the acoustic nature of the tokens and possible perception difficulties, listeners may have tended to use the spelling pattern that is easier and that corresponds to words with the lax vowel (e.g., 'sit' instead of 'seat').

However, if we scrutinize the data, other factors seem to account better for the transcriptions provided by the listeners. As aforementioned, the results displayed in Figure 6 indicate that the target words with the highest percentages of correct responses are actually those that displayed high frequency ranks in the COCA corpus and whose production by the BP speakers did not contain affrication of the final alveolar stop. Coincidently, three of these words contained the lax vowel with the consistent spelling.

In general terms, the results have shown that assessing the intelligibility of particular L2 sounds is a complex endeavor. In addition to the acoustic information, listeners rely on semantic and syntactic cues provided by the

10 Brod and Seara (2013) report the following normalized values for BP /i/ formants: F1 = 338; F2 = 1997. The authors also report duration of 40 ms for both male and female /i/.

carrier sentence, as well as lexical frequency, to retrieve the target words. In the absence of semantic information and faced with conflicting acoustic information, even more proficient listeners have difficulty when asked to understand and transcribe less frequent words with the lax and tense vowels. The results also indicated that lack of semantic cue plus transfer of L1 phonetic processes to the production of L2 codas or onsets had a negative effect on listeners' performance, especially if the target word was not highly frequent.

Closing remarks

Overall, this paper sheds light on the multitude of interacting factors that influence each other, acting upon the language system and giving it dynamicity. In this paradigm, the results demonstrated that more frequent items (and also more familiar) were more easily transcribed, thus having higher intelligibility scores, which shows that frequency influences the representation of word categories, as predicted by usage-based approaches. Overall, these results attest that language intelligibility can be determined by the listeners' knowledge about the frequency behavior of lexical items in the language (ELLIS, 2002). Still, syntax and semantic cues were found to influence listeners' performance on the intelligibility test.

Notwithstanding, the results from this study are based on performance, rather than language processing. Only a processing experiment, such as a priming task that measures implicit learning, can accurately reveal how exemplars influence language learning (MARINIS, 2003). Moreover, psycholinguistic tasks that focus on semantic and syntactic influences on speech intelligibility would be able to reveal accurately to what extent these systems interact with each other when speech is processed. In the present paper, we conducted a mere exploratory analysis with these variables bearing in mind that they might have posed some influence during the intelligibility task, given that the original study conducted by Gonçalves (2014) was not designed to test these variables.

Similarly to what Trofimovich *et al.* (2012) point out, another shortcoming of the current study is that the input language users received while learning the L2 was not directly examined. We made use of a corpus to observe frequency counts, assuming that these reflect some properties of input. An attempt to compensate for this was to employ a word familiarity test, as this could reveal how familiar subjects were to the tested items.

However, the scale did not perfectly reflect how familiar the language items were, and this might have blurred to some extent the relationship between frequency and familiarity, which was found to be strong despite scale shortcomings.

Not having tested the sentences used in the intelligibility task with no audio is another limitation the present study carries. By asking subjects to complete them without any aural aid, we would have been able to observe whether the cotext would trigger any trends in listeners' responses.

Research can profit from usage-based approaches to investigations on intelligibility, as this can elicit how frequency can shape cognition, as well as more of second language acquisition and processing can be understood from such a stand. Researchers will then be able to develop a nuanced view on the nature of linguistic representation and how the many variables that act upon this system interact. Interestingly, the importance of usage events, as discussed by Bybee (2006), relies greatly on the fact that they "not only lead to the establishment of a system within the individual, but also lead to the creation of grammar, its change, and its maintenance within a speech community" (p. 730).

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