Rev. Estud. Ling., Belo Horizonte, v. 27, n. 1, p. 165-189, 2019

Unraveling Foreign Accent Prosody: Production and Perception of Lexical Stress in English by Brazilian Portuguese Speakers

Desvendando a prosódia do sotaque estrangeiro: produção e percepção do acento tônico no inglês por falantes brasileiros

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Abstract: many adults who learn a second language have a foreign accent to some extent. The misproduction of lexical stress (LS), which plays an important role in the prosodic structure of speech, contributes to the perception of a heavier foreign accent. Twenty-four Brazilian Portuguese (BP) speakers of English of four different self-reported levels underwent tests of production and perception of LS. This study aimed to describe how production and perception of lexical stress happen to BP speakers of four different self-reported levels. Acoustic data, as well as the percentage of scores in stress placement, were collected and compared to the production of a native speaker of American English (AmE). Syllable duration, total intensity, and relative intensity were the most important parameters used by the BP speakers to stress syllables. Hits in the perception task were greater than the production task, overall. Initially stressed words had the greatest hits in both production and perception. Overall, the BP speakers from this use, in AmE, the same acoustic parameters used in BP for signaling LS. The production, in regards of acoustic parameters use, gets closer to the native when the proficiency level increases. Cognate words were not relevant in the acoustic parameters choice of the speakers, but they were relevant for the stress position hits.

Keywords: foreign accent; lexical stress; acoustic phonetics.

eISSN: 2237-2083
DOI: 10.17851/2237-2083.27.1.165-189

Resumo: muitos adultos aprendizes de uma L2 possuem algum grau de sotaque. Contribui para esse sotaque a não adequada realização do acento tônico (AT), que tem papel preponderante para a estruturação prosódica da fala. 24 falantes do português brasileiro (PB) de quatro níveis autorreferidos de inglês americano (IA) participaram de testes de produção e percepção de AT. Os dados acústicos de produção dos participantes, assim como os escores na marcação da posição acentual foram coletados e comparados com um sujeito nativo. Os parâmetros acústicos de maior relevância para a realização do AT dos falantes do PB foram a duração, intensidade total e intensidade relativa das sílabas acentuadas. Os escores de percepção foram maiores do que os de produção, de modo geral. As palavras com acento inicial foram as que tiveram maior número de acertos tanto na produção quanto na percepção. Os falantes nativos do PB de todos os níveis empregam os mesmos parâmetros acústicos de acentuação da L1 no IA, sendo que estes tendem a se aproximar dos do nativo à medida em que o nível de inglês aumenta. O cognatismo não foi relevante para o uso dos parâmetros acústicos empregados na marcação do acento, mas influenciou os escores da posição acentual.

Palavras-chave: sotaque estrangeiro; acento tônico; fonética acústica.

Submitted on March 8th,

Accepted on June 11th, 2018

1 Introduction

Most of the adults who learn a second language (L2) have a foreign accent to at least some extent, especially if L2 phonetics/phonology differ significantly from his first language (L1) (FLEGE; HILLENBRAND, 1984). Foreign accents are perceived when native speakers of a language detect divergences in the phonetic production at both segmental and suprasegmental levels (FLEGE, 1995). Over the years, many factors have been considered relevant related to foreign accent: age of learning, time of residence in an L2 speaking country, sex, formal instruction level, motivation, aptitude for language learning, and the amount of L1 use. Nonetheless, the only predictive variables authors seem to agree upon are age of learning and amount of L1 use. Although it's been vastly discussed the existence of a single critic period

to learn an L2 unaccented (LENNEBERG, 1967; SCOVEL, 1969, 1988; PATKOWSKI, 1980, 1990), other studies present the hypothesis of many critic periods or yet sensitive periods throughout one's life, effecting the linguistic abilities of the subject (FATHMAN, 1975; SELIGER, 1978; WALSH; DILLER, 1981, LONG, 1990; HURFORD, 1991). Although these periods are important to be considered, age is not a limiting factor for the speaker to reach an advanced level of proficiency in an L2. Experiments involving native speakers of Mandarin and Spanish who had arrived in the USA within a few weeks and over a decade have been done. They showed that the production of the English nonnative speakers who had been in the US for a longer time was, overall, as correct as the production of the nonnative speakers who had recently arrived (FLEGE, MUNRO, SKELTON, 1992). Foreign accents may cause uncomfortable situations for the speakers, especially if it involves misunderstandings and if speech intelligibility is affected. A possible mechanism for the rational of foreign accents is the influence of phonetic features of the L1 over the L2 (FLEGE, 1998).

The proximity between two languages causes post-lingual L2 learners to establish an allophonic relationship between sounds that are in fact different in both languages, instead of creating different phonological categories for each language (FLEGE, 1995). That results in distortions in the production of L2's consonants, vowels, and prosody. An example of that occurs when Brazilians palatalize the [t] in English before [i]/[j] (two/too/to [tʰu] being pronounced as [ʧu]). Such distortions are noticed by native speakers of English. At a prosodic level, (suprasegmental), the word *demonstrate* should be pronounced DEmonstrate (in American English). If pronounced demonsTRATE, following the ultimate syllable stress pattern of verbs in the infinitive form in Brazilian Portuguese, an accent will also be perceived.

The aforementioned interaction between phonological systems also occur for suprasegmental features of languages. The rhythmic parameters of speech, despite not easily noticed for nonnative speakers, play an important role in the detection of a foreign accent, being even more relevant than segmental distortions, and syllable structure (ANDERSON-HSIEH, 1992).

Primary lexical stress, which we will simply call here Lexical Stress (LS) is the lexical mark that is made in the speech chain in order to realize prominence of a syllable in relation to another syllable within

a word (ARCHIBALD, 1993; MAJOR, 2001). This mark is usually realized by changing parameters such as fundamental frequency, duration, and sound intensity of a syllable. Every language with LS ponders differently the weight each parameter has on the realization of stress. LS is fundamental for the segmentation of continuous speech signal and its recognition, given by the prosodic structure. The alternating pattern of strong and weak syllables helps determining the constituents within a phrase (CUTLER, 1986, 1989; CUTLER e NORRIS, 1989). LS is also considered as a facilitator in the lexical access (GROSJEAN & GEE, 1987). The misplacement of word stress leads to problems in lexical decision, which contributes to establish a relationship between the acoustic image of words and its mental representation. The LS is more considered to speech recognition, especially concerning the initial lexical activations of the possible candidates and in the disambiguation of the selected candidates (COLOMBO, 1991). In order for us to discuss LS by Brazilian speakers, it is needed to discuss the acoustic realization of this prosodic phenomenon in both languages.

LS in English

English is a language with varied stress position (HELAL, 2014; GIMSON, 1980; LADEFOGED, 1982), and stress can fall on any syllable of a word. The initial stress pattern (left-most), however, is the most predominant one (80% of the words), especially in disyllabic words (CUTLER; CARTER, 1987). Besides, in English there is a frequent relationship of stress with derivational morphology in disyllabic word pairs that have the same segmental constituents, making different noun/verb pairs: LS in the first syllable indicate nouns (e.g.: PROtest), and LS in the last syllable indicate verbs (e.g.: proTEST). LS in English is realized by contrasting vowel quality (full/reduced vowel), as well as the frequent increase in F0, sound intensity, and duration. Other than the prosodic features, LS can also be realized by changing parameters at the segment level. The vowel within a stressed syllable is always full, whereas surrounding unstressed vowels are frequently reduced as a schwa.

Plag (2011), compares primary and secondary stress in AE in words both carrying and not carrying pitch accents, reaffirming the role of duration to mark stress in AE. Although the parameter was relevant

to mark stress, it was not significantly different between the two levels of stress studied.

In 1996, Sluijter and van Heusen used the noun-verb pairs of AE that contrast in stress in eight repetitions of the same stimuli by native speakers of the language. The authors found that the stressed syllables were much longer than unstressed ones, making duration the most important factor to mark stress. Regarding total intensity, stressed syllable were always louder in both conditions studied: in and out of linguistic focus. Nonetheless, when focus was not on the word, the intensity increase was not significant, corroborating the hypothesis the intensity is more related to pitch accent than lexical stress per se. It is widely discussed how important F0 is to mark LS in AE, if it is not more related to pitch accent, just like total intensity. However, its importance to mark LS is undeniable. When prominence happens, the peak of F0 or a positive inflection of the F0 contour occurs.

LS in Brazilian Portuguese

In Brazilian Portuguese (BP), as well as in English, stress is also contrastive (CONSONI, 2006), as can be clearly observed in the examples *SAbia* (wise person, female), *saBIa* (past tense of "to know", third-person singular), and *sabiA* (thrush bird). There are three possible primary stress positions in BP (the three last syllables of a word), and the distribution of syllables stressed in the penultimate position comprises approximately 63% of the stress pattern of the language (ARAÚJO *et al*., 2007). Duration is the most important parameter to mark stress in BP, followed by fundamental frequency and intensity as described by Fernandes (1976), who studied the phenomenon in assertive sentences, besides other authors (MASSINI-CAGLIARI, 1992; BARBOSA, 1996). The acoustic correlates vary in function of the prosodic strength of a word in a sentence, more than a pre-determined stress pattern, inherent to a word. When a word is in a week prosodic group, LS happens by an association between intensity and duration. When an oxytone is in a weak prosodic position within a sentence, there is no specific parameter to be used to mark LS. Fundamental frequency has its relevance for marking prominence in BP, but much more related to the phrasal level (MORAES, 1998).

It is evident that AE and BP differ greatly from one another considering LS, not only on the stress pattern but also on the nature of the acoustic realization of stress. Therefore, this article proposes to study the realization of LS in AE by BP speakers that believe to be of different levels of proficiency, as well as to analyze how these participants perceive LS spoken by native speakers of English, trying to establish a possible correlation between production and perception.

2 Methods

In this research, 24 participants (15 female, 9 male) met the inclusion criteria: be Brazilian, native speaker of BP and have some knowledge of AE. After fully reading and signing the consent terms, all participants responded to a brief questionnaire with information regarding their study of English, such as where they had studied, for how long, and if they had ever lived in an English speaking country, so that we could establish a sociolinguistic profile of the studied population. In the end, the participants had to attribute a grade they believed to reflect their proficiency level in English. This grade was an integer number from 1-4, four being very fluent. After that, we ran the production and perception experiments.

The participants were distributed in 7, 5, 7, 5 within the N1, N2, N3, and N4 levels, respectively, which represent a progressive scale of self-reported proficiency levels. Out of all of them, 66.7% (n=16) reported to know English from private language schools, and only one subject (N3) claimed to have self-taught the language. The great majority (88%) never had lived in an English speaking country.

In order to compare the production data, a native speaker of English was recorded for the experiment. The male speaker was natural from Minneapolis-MN, USA, being 22 years old at the time of the study, had been living in Brazil for about six months, and had studied BP prior to his arrival in Brazil. Even though we only used one American subject, our analyses (that will be shown in the Results section) confirm that he behaves linguistically as a standard speaker of English, and his English was not influenced by his BP knowledge.

2.1 Production

A list with 45 three-syllable words of AE (22 cognates; 23 noncognates- APPENDIX I) was presented through a slide presentation to each subject within the carrier-sentence *say____again*. We did not control for the affixes of the words but we tried to keep the proportion of the stress pattern distribution, thus the majority of words were initially stressed. The slides were randomized by the computer and the sentences appeared one at a time on the screen. The participants were required to read them as natural as possible. This step was recorded at a sampling rate of 44.1 kHz, at 16 bits. The recordings were not interrupted and the speakers could repeat a sentence when they were disfluent or hesitant in a sentence. The target words were extracted from the sentence and the annotation layers for the acoustic analyses on Praat (BOERSMA; WEENINK, 2018) were "word", "syllable", and "tonicity". The acoustic parameters: F0 median (in Hertz), duration (in ms), total and relative intensity (both in dB) were extracted for each syllable using a script developed by Barbosa (2016), and the statistical analyses were carried using the R software (R Development Core Team, 2011). The mentioned relative intensity is a correlate of the vocal effort in one's production, obtained with the difference between the energy to the maximum frequency used and the energy until 400 Hz (TRAUNMÜLLER; ERIKSSON, 2000). The measures for each syllable were associated with tonicity factor (levels: stressed and unstressed), cognate relationship (levels: cognates and noncognates), and self-reported proficiency level (N1-4).

2.2 Perception

The words used in the production task were pronounced by the American speaker and recorded in order to create the perception task, using another script in Praat. The Brazilian participants had to wear supra-aural headphones to improve their focus. On the screen, three options would show up to them, in the form of rectangles that indicated the stressed syllable position. Their task was to click on the rectangle that better represented their perception of the strongest syllable in the word: in the beginning of the word (P3), in the middle (P2), or the last part of the word (P1). When clicking on an option, the next stimulus would automatically play. Each stimulus was presented three times (in different moments) in order to analyze the consistency of their responses

for the same stimulus. The responses were extracted and computed for each subject, and they were only considered valid if the same position for a stimulus was chosen at least two out of the three presentations.

The production data underwent statistical analysis. Since the data did not pass the conditional criteria for a regular 2-way Analysis of Variance (2-way ANOVA), we used a non-parametric technique, the Scheirer-Ray-Hare (SHR), an extension of the Kruskal-Wallis test, with a significance level of 0.05. We also used this significance level in the post-hoc tests of Wilcoxon with the Bonferroni correction, that is, for the models with significant factors only. Spearman's correlation test was used to compare scores of the production and perception experiments. The minimum significant difference between the different levels of English for each parameter was calculated with the Duncan test, in order to verify if the average values of each parameter was close enough to group the levels (N1-4) in a category close to the native speaker.

This research was approved by the institutional review board of the Faculty of Medical Sciences of the University of Campinas (CEP- FCM/UNICAMP), under the registration number CAAE: 58189216.4.0000.5404.

3 Results and Discussion

After collecting all the data, we present in this section the acoustic data from the Brazilians, the native AE speaker, and the scores obtained in the production and perception tasks.

3.1 Description of the production data of the participants and the native AE speaker

The mean values of the acoustic parameters of the native AE speaker are shown in Table 1, showing an increase in fundamental frequency, total intensity, and especially duration in the realization of LS, while relative intensity did not change with tonicity.

TABLE 1 – Raw acoustic data of the native AE speaker (s0= unstressed; s1= stressed; dif= difference stressed - unsetressed)

		Acoustic Parameter											
		Duration (ms)			F0 Median (Hz)			Total Intensity (dB)			Relative Intensity (dB)		
		s0	**s1**	**dif**	**s0**	**s1**	**dif**	**s0**	**s1**	**dif**	**s0**	**s1**	**dif**
Native		197	235	38	90	97	7	59	64	5	2	2	0

We elaborated four models, one for each parameter (normalized data for duration, F0 median, Total Intensity, and Relative Intensity) and the relationship between the two factors (tonicity and cognate relationship) and the realization of LS. The analysis show that the increased parameters in Table 1 were all significant to mark stress, and the cognate relationship only affected total intensity of the native AE speaker (Table 2), where the noncognates mean intensity was 62 dB against 59 dB of the cognates (p-value<0.05).

TABLE 2 – Results for the non parametric analysis of variances of two factors for the acoustic data of the native AE speaker

	Duration	F0 Median	Total Intensity	Relative Intensity
Native	stressed *p= 0,005**	stressed *p= 0,00005**	stressed *p= 0,009*/* noncognates *p= 0,00002**	-

The acoustic parameter of the participants of all four levels were extracred from the segmented syllables. Table 3 shows that, overall, duration, total and relative intensity were increased to mark stress in English. For levels 1, 2, and 4, F0 median was significantly higher in the unstressed syllables. Yet, the parameter seems to get closer to the American speaker if we consider only two major groups: least proficient speakers (N1-2) and more proficient speakers (N3-4), considering that the distribution within the proficiency levels was merely based on the auto evaluation of their own level of English.

For the parameter syllable duration, the most important parameter to realize LS in BP, all groups increased the parameter in the stressed syllables, and it happened with more emphasis among N1 speakers, with the increase diminishing over the proficiency level increase. The difference between stressed and unstressed syllables is the exact same for the N4 speakers and the native AE speaker (dif= 38 ms).

TABLE 3 – Raw acoustic data of the BP speakers per proficiency level (s0= unstressed; s1= stressed; dif= difference stressed - unsetressed)

		Acoustic Parameter											
		Duration (ms)			**F0 Median (Hz)**			**Total Intensity (dB)**			**Relative Intensity (dB)**		
		s0	s1	dif	s0	s1	dif	s0	s1	dif	s0	**s1**	**dif**
Level	**1**	225	337	112	195	186	-9	68	69	1	8	10	2
	2	217	309	92	202	192	-10	70	71	1	9	11	2
	3	216	287	71	210	213	3	65	71	6	8	11	3
	4	232	270	38	186	181	-5	71	73	2	8	11	3
	mean	222	303	81	199	194	-5	69	71	2	8	11	3
	Native	197	235	38	90	97	7	59	64	5	2	2	0

The Brazilian population increased total and relative intensity in all levels, more evident in N3 (dif= 6 db). The native AE speaker did not use relative intensity to differentiate the tonicity of the syllables, but the difference between syllables of different tonicities (dif= 5 dB) is close to the N3 speakers.

The results in the SHR models for all four parameters, of all four levels of proficiency are shown in Table 4.

TABLE 4 – Results for the SHR models for the acoustic data of the speakers

		Duration	F0 Median	Total Intensity	Relative Intensity
Level	1	stressed *p<0,01*	unstressed *p= 0,0008*	stressed *p=0,009* cognate *p<0,01*	stressed *p<0,01*
	2	stressed *p<0,01*	unstressed *p=0,006*	cognate *p=0,002*	stressed *p<0,01*
	3	stressed *p<0,01*	-	stressed *p<0,01* cognate *p<0,01*	stressed *p<0,01*
	4	stressed *p<0,01*	-	stressed *p<0,01* cognate *p<0,01*	stressed *p<0,01*
	mean	stressed	unstressed	stressed/cognate	stressed
	Native	stressed *p= 0,005**	stressed *p= 0,00005**	stressed *p= 0,009*/* noncognate *p= 0,00002**	-

The acoustic parameters presented in Table 3 are in fact significantly higher in the stressed syllables of the BP speakers, except the increase in F0 median that had happened for N3 and the slight difference for N4. This findings reveal that the realization of LS by Brazilian speakers begin with a significant negative difference in F0 of lower least proficient speakers, changing to no difference between them in more proficient speakers.

The difference in relative intensity of Table 3 is significant for all four levels, meaning that vocal effort is indeed relevant when marking stress in English of BP speakers.

The SHR analysis show yet, that for all groups, the cognate relationship was significant to the realization of stressed syllables, with the stressed noncognates being louder.

To investigate the explained variation of each factor, we calculated the effect size for each parameter per level (Table 5), in order to evaluate

how each factor (tonicity or cognate relationship) helps determine the mean values of each acoustic parameter.

TABLE 5 – effect sizo of the acoustic parameters by the factors Ton= tonicity and Cog= cognate relationship, in %. (DUR= duration, F0MED= F0 median, TOTINT= total intensity, RELINT= relative intensity)

	DUR		F0MED		TOTINT		RELINT	
	Ton	**Cog**	**Ton**	**Cog**	**Ton**	**Cog**	**Ton**	**Cog**
N1	22,3	NA	1,3	NA	0,7	5,3	2,4	NA
N2	14,2	NA	1,2	NA	NA	1,4	3,6	NA
N3	11,6	NA	NA	NA	3,2	4,4	7,1	NA
N4	3,8	NA	NA	NA	4,3	4,2	2,7	NA
Native	5,6	NA	12	NA	13,6	5,1	NA	NA

NA= factor was not significant in the SHR analysis.

The data in Table 5 show that part of the variation that can be explained by tonicity in N1 is significantly higher for duration than F0 and total and relative intensity. Therefore, the most important parameter used to mark stress in the L1 is also used for the same function in L2. The explained variation for duration diminishes as proficiency level increases, reaching only 3.8% for N4, very close to the native AE speaker (5.6%). However, none of the BP groups has a close production to the native AE speaker in the parameters with more explained variation for him (F0 median and total intensity). For that account, two things should be considered: our analysis are based in one speaker only, and that in the read sentences was always in the condition of linguistic focus. This condition ponders the weight of F0 and total intensity to a higher degree in stressed syllables in AE (SLUIJTER, 1996).

The Duncan's Multiple Range Test (Table 6) was done in order to analyze how the distribution of the acoustic parameters of the BP speakers related or not with the same parameters of the native AE speaker, grouping the means of each parameter according to the minimum significant difference between them, represented by a letter. Groups with the same letter do not differ significantly from each other. For duration, N1 and N3 differed from each other, with N2 and N4 having means that are close to

the two levels, and N3 was the closest to N4. It is necessary to say that the native AE speaker was a male, with fundamental frequency that is naturally lower than women's (because of anatomical particularities of each sex), and that certainly had an influence in our results, given that most of the BP speakers were female. For total intensity, N1, N2, and N4 were independent groups, and N3 was grouped with N2 and N1. The latter was the one that was the closest to the American speaker. For relative intensity, all groups were put together, being very different from the American speaker (BP mean relative intensity was 9 dB, and the AE speaker's was 2 dB).

TABLE 6 – resulted groups from the Duncan's test per parameter

	DUR	F0MED	TOTINT	RELINT
N1	a	bc	c	a
N2	ab	b	b	a
N3	b	a	bc	a
N4	ab	c	a	a
Native	c	d	d	b

We used for this research the data of only one native AE speaker that was available at the time of the study. Even though he behaved as an expected speaker of English described in the literature regarding LS, we have to understand the limitations that are posed when we make analyses and comparisons with much larger groups with only one subject (and consequently only one sex).

3.3 Production task scores

The stress placement of the words produced by the Brazilians was compared to the expected stress position of each word to calculate the production score of each level. For this analysis we considered other than the self-reported level of proficiency the cognate relationship of each word and stress position, in order to understand if a particular stress position was considered easier for the speakers.

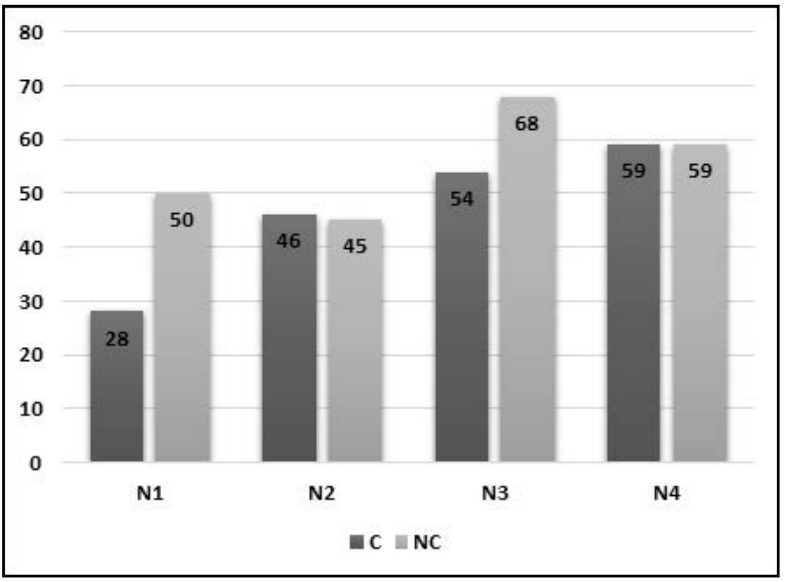
The overall score (of the four levels combined) was 51%, and the scores in this section disregard the acoustic parameters used to mark

stress. The participants placed stress correctly in 44% of the cognate words and 53% of the noncognates.

The analyses per stress position increased proportionally to the proficiency level, with a slight 2% fall from N3 to N4 (N1: 39%; N2: 45%; N3: 62%; N4: 60%). It is expected such increase considering that the higher the proficiency level, the more familiar with the actual stress position the subject is.

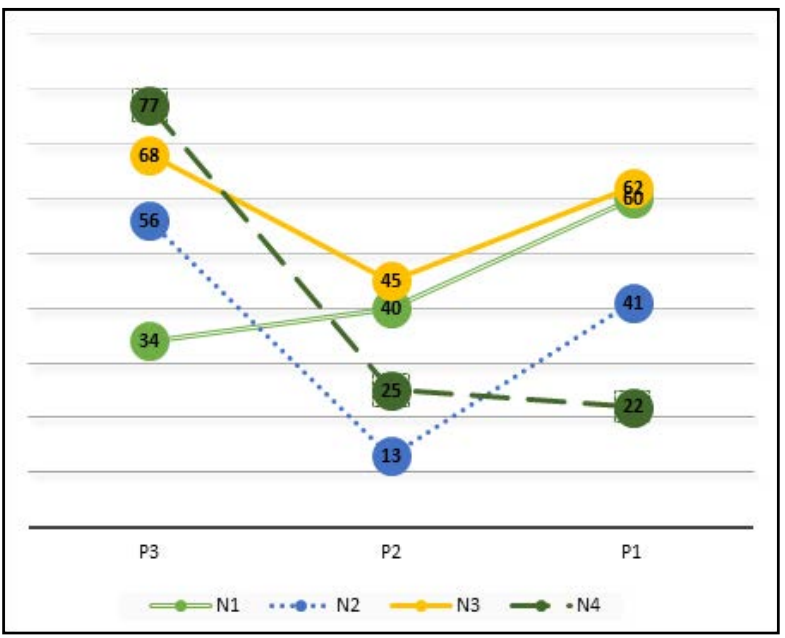
Comparing the scores of cognates in the production task, we can see that it was easier to get the right stress position in the noncognates (53%) than it was for the cognates (44%) corroborating our hypothesis that the participants, when reading a cognate word, are influenced by the word in BP, ignoring the stress position in AE. Separating this analysis per level (Graph 1), we can observe that this difference persists, but it reduces as the level of proficiency increases. That is evident if we compare the extreme groups (N1 and N4), where we have 28% of the cognates and 50% of the noncognates for N1 and 59% for both categories for N4.

GRAPH 1– Percentage scores of the word in the production task per level (N1, N2, N3 e N4) and cognate relationship (C= cognates, NC= noncognates)



The three possible stress positions were P3 (initial stress), P2 (medial position), and P1 (last syllable). The percentage analysis shows that, in general, the easiest position to assign stress was P3 (56%), followed by P1 (50%), and P2 (32%). Reorganizing the data per level (Graph 2), we can see that for the more proficient speakers, the initial position (P3) had the highest scores, and decreases as the expected stress position moves towards the end of the word. That is probably associated with the common stigma that most of the three syllable words in English bear stress in the first syllable (CUTLER; CARTER, 1987; CUTLER, 2015), which is true and justifies the high score density in P3. However, that assumption says that when stress is actually in a different syllable than P3, even N4 speakers ignore the right stress placement.

GRAPH 2 – Percentage of scores in the production task per level (N1, N2, N3 e N4) and stress position (P3= initial, P2= medial, P1= final)



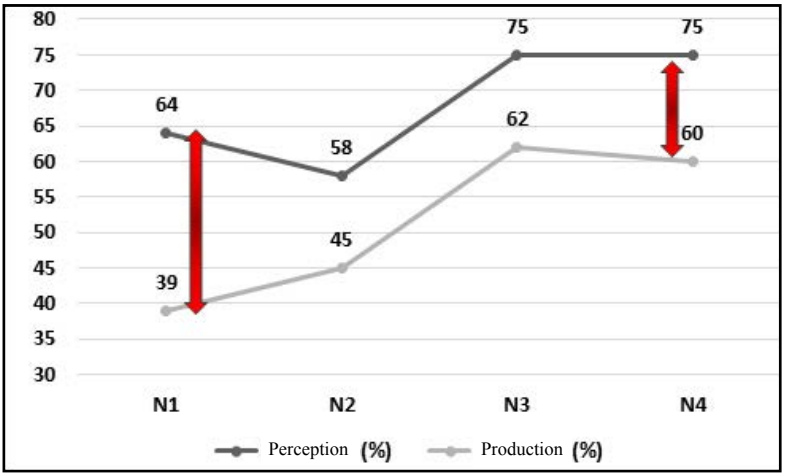
As for the least proficient speakers, trying to assimilate the influence of L1 in their production, we can see low scores for P3 (34%), comprehensible once this stress pattern is unusual in BP (MASSINI-CAGLIARI, 1992). Unlike N4 speakers, the percentage of P1 scores tend to be higher for the N1-2 groups.

3.4 Perception task scores

The perception tests were subsequent to the production recordings, and the same words were used as the stimuli for it, to maintain the experimental control. In this multiple forced choice test, the participants of all levels had to choose the stress position they thought to be the strongest. The general percentage of correct answers was 68%, higher than the scores in the production test (51%), and the cognates (70%) were slightly higher than noncognates (67%).

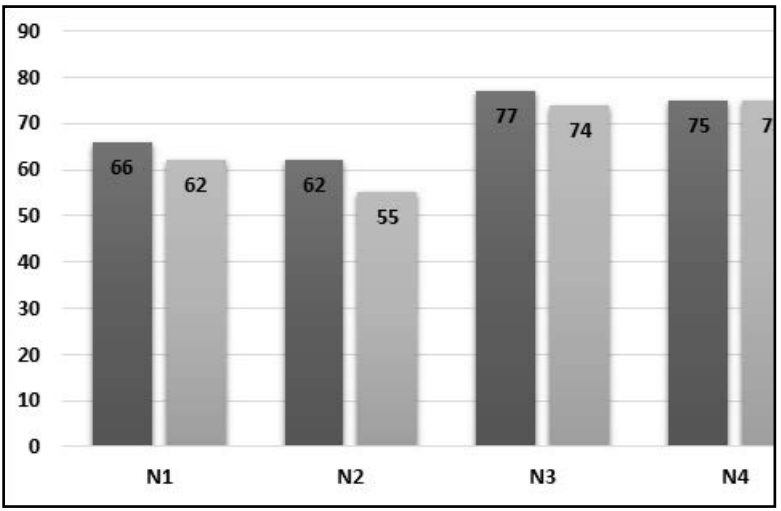
The scores in the perception test were N1: 64%; N2: 58%; N3: 75%, and N4: 75%. Just like in the production test, the scores tend to increase along the proficiency level, but two things are clear when observing Graph 3: scores of all levels are higher than the production test's for all levels, and they tend to stabilize with the level increase. In other words, although perceiving LS is apparently easier than producing it correctly, the difference between production-perception scores reduces as proficiency levels increase. This relationship between production-perception was also found in previous studies. Brawerman-Albini and Becker (2014) made a production and perception study in English with an uncommon stress pattern in BP, stresses in the fourth and fifth syllables, from the end. All words were cognates with Portuguese. The relationship found between production and perception (28% and 85%, respectively) was parallel to our results for the same category (cognates), being 47% and 70% for production and perception, respectively. The population in the mentioned study did not count with advanced level speakers.

GRAPH 3**:** Comparison of the perentage scores in the prodution and perception tests per level (N1, N2, N3 e N4)



The analysis of the scores in function of the cognate relationship shows that despite some predominance of the noncognate scores in the least proficient speakers, like in the production test (difference C-NC for N1 production= 22%), it decreases in the perception test (difference C-NC for N1 perception= 4%).

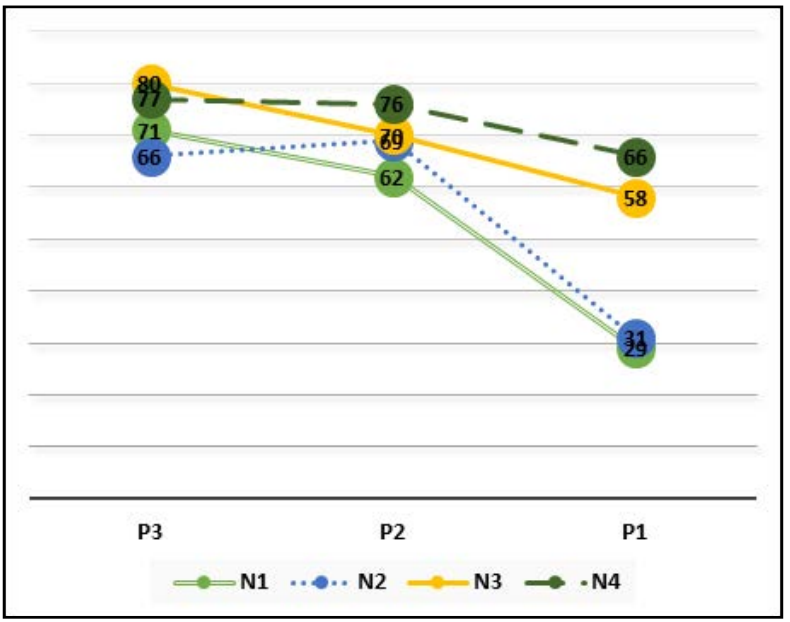
GRAPH 4 – Percentage of scores in the perception test per level (N1, N2, N3 e N4) e cognate relationship (C= cognates, NC= noncognates)



It is interesting to note that N4 speakers also increased their scores in the perception task, but still LS in AE was not perceived differently whether the words cognates or noncognates (difference C-NC= 0%). The comparison between both graphs allows us to observe a slight inversion in the scores of cognates and noncognates in N1 and N3 in the production and perception tasks: in the production task, noncognates scores were higher than cognates, and the contrary occurs in the perception task.

Graph 5 shows the percentage of LS perception scores according to level and stress position. For perception, P3 scores are more concentrated in the 66-80% area, whereas the same category was much wider for production, 34-77%.

Graph 5: percentage of scores in production perlevel (N1, N2, N3 e N4) and stress position (P3= initial, P2= medial, P1= final)



The scores in the other stress positions were lower and more disperse than for P3, and N4 speakers scored 66% of words with final stress, whereas N1 speakers did only 29%. We would like to emphasize

that one possible reason why many BP speakers classified some words as P3 when they were in fact P1, is that many of these words had secondary stress in P3, so that when the word was heard, they immediately clicked on P3, when the primary stress was actually in P1.

3.5 Production x Perception

The scores in the perception test were higher for all levels of proficiency when compared to the production test's scores. In order to verify a possible correlation between scores of both tasks or if they work independently from one another, we performed Spearman's correlation test on the overall scores for each level in each test. Even though there was a positive correlation of 0.87, the low sample size made the test non significant (p-value> 0.05).

4 Conclusion

Native BP speakers of all levels employ the same acoustic parameters of lexical stress of the L1 in AE (duration and intensity). The acoustic differences made to stress syllables that happened in production tend to get closer to the AE speaker here studied, when it comes to higher proficient level speakers. The cognate relationship of words only affected the total intensity of syllables when assigning stress. The relationship between the level of proficiency and the performance on the production task happens parallel to the findings of previous studies that compare the age of learning of foreigner speakers immersed in L2 speaking countries (FLEGE, MUNRO, SKELTON, 1992; FLEGE, 1995), in which the most proficient speakers get closer to the production of a native speaker of the L2.

The participants of this study found it easier to perceive the correct LS than assigning the correct stress in their production, given the perception scores were higher in all groups (even though this production-perception difference reduces drastically from N2 on). Even though the cognate relationship of words did not influence the acoustic parameters used in the production of LS (except for the total intensity), there are differences in the percentage of scores in production. Least proficient BP speakers scored 50% of the words that did not have a reference in Portuguese, but only 28% of the words that did. That did not happen to higher level speakers. This corroborates the hypothesis of the influence that L1 exerts (FLEGE, 1995), especially in speakers of lower levels in

the L2. These speakers ignore the possible stress positions when they are not in the exact position as the reference word in their L1, causing them to misplace stress. When it comes to a noncognate word, they tend to do the task more criterious, increasing score rates. Our findings confirm that: initially stressed words (less often in BP) had much higher scores in both production and perception.

For us to make any further inferences about the production of BP speakers in AE it is necessary to make some adjustments: objectively control proficiency level (with screening tests, for example), increase the number and sex of AE speakers controls, and the morphological aspects of the words in the corpus. Monomorphemic words comprised about 7% of our corpus, while all the others were bimorphemic. Even though this have been controlled in our current studies, we also bring attention for the possibility of the secondary stress of words interfering with the decisions made by the participants, as previously discussed.

Authorship declaration

This work counted with the contribution of authors Filipe Modesto and Plinio Almeida Barbosa, proposing the study. F. Modesto organized the experimental methodology and data collection under supervision of P. Almeida Barbosa, chair of the research group, who participated actively in the data analysis, text writing and proofreading of the final version. English translation was carried by F. Modesto. Both authors are members of the Study Group for Speech Prosody of IEL/UNICAMP.

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APPENDIX I – List of target words

Target Words	
COGNATES	NONCOGNATES
Photograph	Fiance
Basketball	Dangerous
Sympathy	Employee
Positive	Saturday
Portuguese	Betrayal
Musical	Demeanor
Amplitude	Appraisal
Metaphor	Spendable
Persistent	Meaningless
Protestant	Furthermore
Resume	Challenger
Abstinence	Mastery
Resistance	Seasonal
Interact	Allowance
Demonstrate	Edible
Memorize	Mispronounce
Summarize	Overact
Fantasize	Understand
Energize	Reachable
Authorize	Standardize
Specify	Underact
Dignify	Overprice
	Outbalance