Original Article

CRITICAL PERIOD AND PHONOLOGICAL ACQUISITION OF ENGLISH BY BRAZILIAN SPEAKERS

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▪ ABSTRACT: This article discusses the influence of age of acquisition on the process of learning a foreign language. We analyzed the acquisition of three phonological processes in English by speakers of Brazilian Portuguese and applied experiments on fricative voicing, stress shift and stress assignment to participants at three levels of proficiency: basic, intermediate and advanced. The results demonstrated that the age factor was relevant in two processes (stress shift and stress assignment) – at least at certain levels of proficiency. On the other hand, fricative voicing was not acquired by Brazilian speakers in any level of proficiency, regardless of age of acquisition.

▪ KEYWORDS: Phonological acquisition. English. Brazilian Portuguese. Second language. Critical period.

Introduction

The age factor is a widely discussed issue in L2 acquisition research. Evidence points to the fact that the later a learner is exposed to a second language, the more his/her mother tongue may influence his/her performance in the target language, and the less likely such speaker is to achieve a similar competence to that of a native speaker.

With regard to L1 acquisition, rare cases such as that of Genie (CURTISS, 1977), a girl who was deprived of any linguistic input between the ages of 1;6 to 13;7, have demonstrated that late acquisition of the mother tongue may cause irreversible damage to language skills. When, at the age of 13, that girl finally received linguistic input, her vocabulary grew significantly, but her intonation remained somewhat unusual. Furthermore, according to Curtiss (1977), although the girl was quite communicative, she could not use the rules of grammar correctly, i.e. she could not learn syntax, although she had a clear semantic ability. The same pattern of decline in language

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learning is shown in Newport (1990). The author analyzed data from native speakers of Japanese and Mandarin who had acquired English as L2 and their performance in the tests was significantly affected by the age of arrival in the USA, showing a great decay in the acquisition (especially in phonology) for the ones who began to acquire English after 15 y.o

Evidence found in late acquisition of L1 and L2 supports the existence of a "critical period" for language development, after which native competence would be inaccessible to learners who are past a certain age. According to Lenneberg (1967), this period ends at puberty, when brain lateralization is complete and there is a reduction in the neural substrate required for language learning.

In previous studies, e.g. Long (1990) and Bongaerts, Mermen and Van der Slik (2000), it has been argued that phonology is the major factor that is affected by age, because it is the only aspect of language performance that involves neuromuscular factors and, therefore, has a physical reality. Authors such as Fromkin, Rodman and Hyams (2003) and Bialystok and Hakuta (1999) prefer the term *sensitive period* for language acquisition rather than the aforementioned *critical period*. In their view, a *sensitive period* entails a more gradual decrease in the ability to acquire languages.

In addition to the acquisition period, L1 may also affect the acquisition of L2. According to Kuhl (2004), acquisition of first language patterns ultimately interferes with the learning of new patterns – e.g. those of a second language – because they are different from the "mental filter" previously established during first language acquisition. The author explains that, by the age of five months, babies are able to distinguish virtually every possible phonetic unit in the world's languages (about 600 consonants and 200 vowels), but this skill is gradually replaced with an ability to distinguish the specific sounds of the mother tongue. During language acquisition, children learn how to group this variety of possible phonetic units into phonological categories of the language to which they are exposed, and they statistically compute the input received to determine the structure of L1. It is precisely the consolidation of these phonological categories of L1 that eventually hinders the perception and, consequently, the production of L2 sounds. Therefore, one should be careful when making generalizations about L2 acquisition, as the grammatical features of L1 also have to be considered.

Phonological Processes

To investigate whether onset age of second-language acquisition has any influence on the production of Brazilian learners of English as a foreign language, this article reports an analysis of the acquisition of three phonological processes of English: *voice assimilation*, which occurs in both languages, but in different ways; *stress shift*, which occurs very similarly in both languages and whose acquisition could provide evidence of the transfer from L1 to L2; and *stress assignment,* which, in terms of parametric acquisition, implies changing the notion of syllable (since the concept of heavy syllable differs in the two languages). Each process will be described in the subsequent sections.

Voice Assimilation

Assimilation occurs when a phonetic property from one segment spreads to another adjacent segment, which may occur either progressively or regressively. In the world's languages, regressive assimilation (which is characterized by the spread of one or more features from one segment to a preceding one) is more frequent, although there are also cases of progressive assimilation (when one or more features of one segment spread to the following segment). In this latter case, these features result from specific phonological contexts or from the phonology-morphology interaction (see LOMBARDI, 1999, p.6).

Voicing is a process that is distinguished, in Portuguese and English, by the direction of spreading. In Portuguese, the process is regressive, occurs with coronal fricatives, and is not limited to any prosodic context (it occurs even between words of different sentences) as can be seen in the examples in (1) (see CÂMARA JUNIOR, 1972; BISOL, 2005; ZIMMER; SILVEIRA; ALVES, 2009; ZANFRA, 2013):

(1) a. pa[s]ta *vs.* ra[z]ga 'briefcase' vs. 'tears up'
b. pa[s] 'peace'
c. pa[s] comum 'common peace'
d. pa[z] eterna 'eternal peace'
e. pa[z] branca 'white peace'
f. Eu vi a[z] menina[z] alegre[z]. Ela[z] não me viram.
'I saw the joyful girls. They did not see me'.

To determine the acoustic characteristics of /s/ in final position in Portuguese, Zanfra (2013) conducted an acoustic analysis of this fricative when followed by a word beginning with a vowel, a voiced consonant, an unvoiced consonant or a pause, in the speech of 23 Brazilians. The results demonstrated that /s/ was produced as [s] in 100% of the cases when the fricative was followed by a pause or a voiced consonant, and as [z] in 96.88% of cases when the fricative was followed by a vowel or a voiced consonant. According to the author, the cases in which the fricative was not voiced when followed by a voiced context (3.12% of the data) may have been influenced by the data collection method *per se*, namely, sentence reading. Informants commonly speak more carefully and more slowly when reading sentences; as a result, they may insert short pauses between the target word and the following context. In short, her research provides acoustic evidence that regressive voice assimilation is, in fact, a categorical rule in Brazilian Portuguese (henceforth BP).

In English, as opposed to BP, voicing of the fricative in codas has a phonological character, as can be seen in the pairs in (2). Furthermore, English has both regressive and progressive assimilation. Regressive assimilation occurs in English when voiced fricatives are devoiced if followed by unvoiced consonants, as in (3) (cf. LOMBARDI, 1999). Progressive assimilation, in turn, occurs when fricative /z/ is preceded by an

unvoiced segment. The examples in (4) demonstrate that the plural, the genitive case and the 3rd person morpheme of the Simple Present tense can be produced as [s], [z] or [iz], depending on the preceding segment (YAVAS, 2006, p.63):

(2) a. bus [bʌs] x buzz [bʌz]
b. fence [fƐns] x fens [fƐnz]
c. his [hɪz] x hiss [hɪs]

(3) [faiv] *five* x [faif tons] *five tons*

(4)	**Plural**	**Genitive Case**	**Simple Present**
a.	[s] cats [kæts]	[s] Jack's	[s] s/he jumps
b.	[z] dogs [dɔgz]	[z] John's	[z] s/he runs
c.	[iz] buses [bʌzəs]	[iz] George's	[iz] s/he catches

In the examples in (5), the sonority of the words *cats, cat's, watches, dogs* is determined by the preceding segment even when they are followed by a segment whose [voice] feature is different (examples from SILVA, 2010, p.34); this provides evidence that such process is progressive in English:

(5) a. cat[s] on the roof
b. cat'[s] ball
c. she wa[ʧiz] TV
d. dog[z] painting

Finally, it should be noted that while regressive assimilation is widespread in English, *progressive voicing* is restricted to the domain of the phonological word and to the three morphological contexts mentioned above.

There are few studies on the acquisition of English fricatives in final position by speakers of BP. Zanfra (2013) investigated the acquisition of phonemes /s/ and /z/ in word-final context, while considering the role of level of proficiency, the following phonological context and spelling. She analyzed data from 23 intermediate and advanced adult speakers, and the results indicated that the phonological context affects the results, but they were not influenced by level of proficiency. In words in which the fricative is not voiced in English (e.g. *bu*/*s*/), Brazilian informants applied voicing when the following context was voiced but did not apply it when the following context was a pause or an unvoiced consonant. In addition, the subjects with both intermediate and advanced level of proficiency transferred the voicing rule of BP into English.

Mendes (2017) investigated the *perception* of English morpheme {-s} by Brazilian speakers of English as L2, taking into account the role of the following phonological context, task length, and the subjects' level of confidence and level of proficiency. Data were collected through a perceptual test containing 120 sentences, each with a target

word with the different productions of {–s}: [s], [z], and [ɪz]. The results found by the author demonstrated that, among the three allomorphs tested ([s], [z] and [ɪz]), [z] presented the lowest rate of correct answers (39%), especially in cases of a fricative followed by an unvoiced context or a pause. These results demonstrate, therefore, that the following context seems to play an important role in the perception of morpheme {–s}, since the percentage of correct answers in the identification of [z] was higher in cases of a fricative followed by a voiced consonant or a vowel.

Fragozo (2017) studied the production of word-final fricatives by observing whether the phonological context and the level of proficiency (among other variables) could affect the results. Thirty learners of English were tested at 3 levels of proficiency. All cases involved progressive assimilation, with words with a voiced segment preceding the morpheme {-s} so that the fricative should be produced as voiced (e.g. *John'[z] video game is an old one; He feed[z] the dog[z] and the cat*). An important point of her research was that the same test was also applied to native speakers of English, and her findings did not point to a mandatory process (see Table 1). Among non-native speakers, the results demonstrated that the subsequent context was the most favorable variable to the production of fricatives: voiced consonants and vowels had a factor weight of 0.93 for the production of the voiced fricative. By contrast, if the following context had an unvoiced consonant or a pause, factor weight was 0.16 and 0.07, respectively.[1] Level of proficiency was also found to affect the results. Interestingly, intermediate-level speakers applied voicing more often and had a higher relative weight than basic and advanced speakers:

Table 1 – Ratio of voicing for native speakers and learners by level of proficiency

Level of Proficiency	Voiced Production		Unvoiced Production		Factor Weight
	N	%	n	%	
Basic	99	16.50	501	83.50	0.44
Intermediate	203	33.83	397	66.17	0.59
Advanced	164	27.33	436	72.67	0.45
Native speakers	185	44.05	235	55.95	

Source: Authors' elaboration.

Stress Shift

Stress shift is a process that occurs in a context of two consecutive stressed syllables, whereby the position of the first stress shifts to an earlier syllable to undo the clash between the two stresses. This process occurs to maximize the alternation of stressed

[1] The preceding context was also relevant, but distinct in different segments. The following factor weights were found: vowel 0.64; fricative 0.50; nasal 0.47; plosive 0.39; liquid 0.34.

and unstressed syllables, in what is known as eurythmy (NESPOR; VOGEL, 1986) or Principle of Rhythmic Alternation (SELKIRK, 1984).

According to Hayes (1984), stress clashes in English are gradually reorganized; adjacent stresses are strictly avoided while close but not adjacent stress may occur (see (6)). Nevertheless, there are cases in which a clash is maintained in English: namely, when the relevant syllables of the context are in different phonological phrases (ϕ)[2] (see HAYES, 1989) – e.g. (7), or when the vowel of the syllable that would be stressed in the case of shift is a *schwa*; the reason is that a reduced vowel cannot be stressed (see LEVEY, 1999) – e.g. (8).[3]

(6) a. fourTEEN - [FOURteen WOmen]ϕ
b. MissiSSIppi - MIssissippi LEgislature
c. seventy-SEven - SEventy-seven SEals

(7) I saw [a raCOON]ϕ [MONday]ϕ * I saw a RAcoon MONday

(8) [maROON COAT]ϕ /məˈruːn ˈkoʊt/ * [ˈməruːn ˈkoʊt]

In English, a stressed syllable has higher fundamental frequency (F0 or *pitch*), longer duration and increased intensity when compared to non-stressed syllables. According to Fry (1958) and Bolinger (1986), the primary correlate of English stress is *pitch*. Cooper and Eady (1986), Levey (1999), Grabe and Warrren (1995), Levey and Lawrence (2992), and Kimball and Cole (2014) conducted acoustic analyses of stress clash contexts. Their results indicate that many contexts are perceived as presenting stress shift when actually nothing occurred acoustically. On the other hand, there are cases of stress shift even in sequences without a severe clash.

Perception studies on BP also point to the process of stress shift in this language (ABOUSALH, 1997; SANTOS, 2002; SÂNDALO; TRUCKENBRODT, 2002; GAYER; COLLINSCHONN, 2007). Abousalh (1997) found that, as in English, shift in BP also occurs within a phonological phrase - see (9). Sândalo and Truckenbrodt (2002) argue that, for stress shift to occur, phonological phrases must have the same prosodic length (the same number of phonological words - (see (10)), and Santos (2002) argues that syntactic factors, such as type of empty syntactic categories, may influence the process. Finally, it is clear that, unlike shift in English, shift in BP solely occurs between adjacent primary stresses - cf. (11):

(9) a. [JeSUS CRISto]ϕ - JEsus CRIsto ‘Jesus Christ’
b. [o DaVI]ϕ [COme]ϕ [bolo de laranja] → * [o DAvi]ϕ [COme]ϕ [bolo de laranja]
‘Davi eats orange cake’.

[2] For the rules of phonological phrase construction, see Nespor and Vogel (1986).

[3] In this article, syllables in uppercase mark the position of stress, * marks phonological ungrammaticality.

(10) a. [caFÉ QUENte]ϕ [queima a boca]ϕ → [CAfé QUENte] ϕ [queima a boca]ϕ
'Hot coffee burns the mouth'
b. [caFÉ QUENte]ϕ [queima]ϕ → * [CAfé QUENte] ϕ [queima]ϕ
'hot coffee burns (it)'.

(11) a. caFÉ requenTAdo → * CAfé requenTAdo
'reheated coffe'
b. jeSUS ressusciTAdo → * JEsus ressusciTAdo
'ressurrected Jesus'

The studies by Barbosa (2002) and Madureira (2002) aimed to find out whether phonological strategies for stress clash resolution also occurred from a phonetic-acoustic perspective. Their results demonstrated that the first syllable in the context of clash is longer (i.e., the occurrence of stress clash is favored) and the fundamental frequency is not changed in these cases.

Silva Junior (2013) compared the production of stress clash sequences in both languages to check whether or not the rhythm of BP could influence the production of English as L2. He analyzed data produced by 3 Brazilian informants with different levels of proficiency (low intermediate, high intermediate and advanced), and 2 North American informants. He found that, instead of resorting to stress shift, Brazilians inserted a silent demibeat *(*SELKIRK, 1984) while Americans preferred the stress shift strategy.

Fragozo (2017) analyzed the production of contexts with and without stress clash by 30 Brazilian learners of English as L2, with 3 different levels of proficiency, and 7 native speakers of English. Her findings demonstrated that the native speakers applied stress shift in almost half of the contexts while Brazilians applied it in 28.7% of the cases - in both groups (with and without stress clash). There was also a gradual increase in the rate of application of stress shift, depending on the speakers' level of proficiency, as demonstrated in Table 2:

Table 2 – Stress shift ratio for native speakers and learners by level of proficiency

Level of Proficiency	Shift		No shift		Factor Weight
	N	%	N	%	
Basic	80	17.5%	378	82.5%	0.34
Intermediate	114	24.8%	346	75.2%	0.45
Advanced	202	43.9%	258	56.1%	0.69
Native speakers	80	49.7%	81	50.3%	

Source: Authors' elaboration.

Syllable and Stress Assignment

In BP, syllable onset, nucleus, and coda can be filled in by more than one segment, but there are no syllables with more than 5 segments (BISOL, 1989). In addition, onset and coda may also be empty. The position of the coda can be filled in with the liquid consonants /R/ and /l/, the nasal consonant /N/, which is often realized through the nasality feature in the preceding vowel, and the coronal fricative /S/. In the case of a branching coda, the possible combinations are /lS/ (e.g., *sols.tí.cio* 'solstice'), /RS/ (e.g., *pers.pi.caz* 'perspicacious') and /NS/ (e.g., *mons.tro* 'monster', *trans.ver.sal* 'transversal'). The nucleus can be filled in by 2 vowels, but there is no distinction between long or short vowels in BP.

Stress in BP is relatively predictable and can occur in the last three syllables. The vast majority of non-verbs (nouns and adjectives) are paroxytones, i.e., they are stressed on the penultimate syllable (63% of the BP lexicon, according to CINTRA, 1997). The group of proparoxytones is smaller (around 6% - CINTRA, 1997). Finally, oxytones (around 18% - CINTRA, 1997) are words that usually end in a consonant. According to Bisol (1992), 78% of words ending in a consonant in the *Delta Larousse Dictionary* are oxytones (e.g., *palaDAR,* 'taste'; *ciVIL,* 'civil') and solely 22% are paroxytones (e.g., *aÇÚcar,* 'sugar'; *MÓvel,* 'furniture'). In the case of oxytones ending in a vowel, most words are loans (*caFÉ*, 'coffee'; *araÇÁ*, 'cherry guava'; *xanGÔ*, 'Shango') and a much smaller group is made up of Portuguese words (*aVÓ,* 'grandmother'; *boCÓ*, 'silly'). With this framework in mind, Bisol (1992) proposes the following rule for primary stress in BP:

Primary Stress Rule according to Bisol (1992, p.34)

Domain: the lexical word

i. Assign an asterisk (*) to the final heavy syllable, i.e., with a branching rhyme.
ii. For the other cases, construct binary left-headed constituents (* **.**) (non-iteratively) near the right edge of the word.

In this rule, stress in BP is assumed to be sensitive to the final syllable - see (12). When the last syllable is not heavy, stress falls on the second to last syllable (see (13)). The cases of proparoxytones, light oxytones and paroxytones with heavy final syllables are treated as marked cases. In the case of proparoxytones, the author proposes that the final syllable should be counted as extrametrical. The final syllable is eliminated and the rule mentioned above is applied (which explains why proparoxytones cannot be found when the second to last syllable has a branching rhyme) - see (14). Extrametricality is also used to account for paroxytones with a heavy final syllable - see (15). Finally, for oxytones ending in a light syllable, Bisol (1992) proposes the existence of an abstract consonant, which can be perceived in derived forms - see (16):

(12) ca.LOR ‘heat’

(13) me.NI.no ‘boy’

(14) PRÍN.ci.<pe> ‘prince’

(15) MÓ.ve<l> ‘furniture’

(16) ca.FÉ$_{Abstract\ consonant}$ >> cafe**t**eira, cafe**z**al
‘Coffee’ ‘coffeemaker’ ‘coffee plantation’

English phonotactics, however, allows more syllable patterns. According to Hogg and McCully (1987, p.35 *apud* COLLISCHONN, 2005, p.105), the minimum structure is VC or VV and the maximum structure is CCVVCC, with 6 segments. Yavas (2006), in turn, includes six more patterns, which also have the maximum number of 6 segments, but he points out that if suffixes are to be considered, syllables can have up to 7 segments (e.g., *sprints)*. These cases are characterized as appendices or violations of syllable structure, because they contain a consonant or a sequence of consonants that solely appear in the initial or final position, but never in the middle of words. Onsets can have up to three segments (e.g. *sprints, splash)*. The nucleus can be simple, branching with a diphthong, or filled in with a long vowel. Finally, codas can branch into up to three consonants (e.g. *midst, next*).

According to Yavas (2006), more than 80% of English disyllabic non-verbs have a paroxytone stress pattern (e.g. *Agent, BAlance, COmmon, FLUent).* As in BP, heavy syllables, i.e. with a branching rhyme (or with a short vowel followed by a consonant in coda position) or with a long vowel (with or without coda)), attract stress. But for word-final position, syllable weight corresponds to the branching nucleus, i.e. a long vowel or a diphthong in the final syllable (e.g. *bamBOO, baZAAR*), or a complex coda (e.g. *abSURD, coRRUPT*). That is, final syllables with a short vowel followed by solely one consonant do not attract stress in English (e.g. *meCHAnic*).

Stress in English nouns, as proposed by Hayes (1985), is stated in (17):

(17) i) If the penultimate syllable is heavy (i.e., it contains a long vowel[4] or a consonant in coda position), stress will fall on this syllable (e.g., a*riZOna, paPAYa, neBRASka, aGENda*)
ii) If the penultimate syllable is light, stress falls on the antepenultimate syllable (e.g., *aMErica, CAmera, CInema, CApital*).

The rule is different for verbs and adjectives - see (18):

(18) i) Words ending in a long vowel will be stressed on the last syllable, as in the verbs *mainTAIN, eRASE* and *deCIDE* and in the adjectives *suPREME,* and *reMOTE*;

[4] For the purpose of stress assignment, tense vowels are considered to be long (see ZSIGA, 2013).

ii) Words ending in a short vowel followed by a complex coda ((C)VCC) will also be stressed on the last syllable, as in the case of the verbs *coLLAPSE, eLECT* and *obSERVE* and the nouns *abSURD, coRRUPT* and *iMMENSE*;
ii) Words ending in a short vowel followed by solely one consonant will be stressed on the penultimate syllable, as in the verbs *Edit, iMAgine* and *reMEMber* and in the adjectives *SOlid, HANDsome* and *meCHAnic.*

While in nouns the last *syllable* is extrametrical, in verbs and adjectives the last *consonant* is extrametrical, hence the stress assignment rule is applied in the same way as in nouns: *construct a trochaic foot aligned with the right edge of the word.*

Since the paroxytone pattern is unmarked in both rules, speakers ultimately use the BP pattern or overgeneralize the English pattern in their productions. According to Zimmer, Silveira and Alves (2009), this happens in words such as *hotel*, whose stress is the same in both languages; however, learners tend to pronounce it as a paroxytone. Silveira (2010) investigated Brazilian speakers' acquisition of stress in simple and compound words of English. Her findings demonstrated that the paroxytone pattern was used in 48.2% of the cases of incorrect assignment of English stress, followed by the proparoxytone (in 24.3%) and the oxytone patterns (21.4%). She also found that the words with the lowest percentage of correct answers were those whose suffixes attract stress to the last syllable (e.g., *employEE, anTIQUE)*. In her study, Fragozo (2017) found that the rate of correct answers was higher in words whose final syllable had a single nucleus, in which the expected stress pattern was the paroxytone one (82.9%), followed by the proparoxytone (62.8%) and the oxytone (62.8%) patterns. Interestingly, there were also cases of stress assignment errors in the control group - with 8.6% errors for paroxytones, 7.4% for oxytones, and 5.7% for proparoxytones. In addition, results demonstrated that the higher the informants' level of proficiency was, the higher their rate of correct answers was as well, as shown in Table 3:

Table 3 – Rate of correct answers of learners - by level of proficiency - and native speakers

Level of Proficiency	Correct answers				Factor Weight
	Yes		No		
	N	%	N	%	
Basic	751	60.9%	483	39.1%	0.35
Intermediate	885	72.4%	337	27.6%	0.47
Advanced	1022	83.3%	205	16.7%	0.67
Native speakers	800	92.16%	68	7.83%	

Source: Authors' elaboration.

Method[5,6]

The informants were seven native speakers of English who had lived most of their lives in their home countries, and thirty Brazilian speakers of English as L2. Brazilian speakers were separated into groups, according to their level of proficiency (ten at the basic, ten at the intermediate and ten at the advanced level). For inclusion in the research, the participants must not have lived in an English-speaking country for more than one month, must have been born to monolingual Brazilian parents, and must not be able to speak any foreign language other than English. Stratified random sampling was used (LEVIN; FOX, 2004). The selection of the Brazilian informants was based on their level of proficiency, and their age when they started having formal exposure to English (before and after twelve years of age). The Common European Framework of Reference for Languages (COUNCIL OF EUROPE, 2001) was used to determine the informants' level of proficiency and assign them to the respective group.

The experiment used a mixture of sentences and phrases with contexts for the three phonological processes described above. Two thirds of the data were always a distractor for the actual target data (one third of all data). The participants were instructed to read each phrase or sentence as naturally as possible. If the participants misread an item of the instrument, kept their mouth away from the microphone, or made too many pauses while reading the sentences, they were asked to reread the phrase or sentence one or more times until the problem could be solved.

In order to allow the observation of assimilation, twenty-eight sentences were created; they included sixty words with a context for the progressive assimilation rule, which is typical of the English language. In fourteen sentences, there were thirty words followed by voiced segments, in which voicing of {-s} could be influenced by the regressive assimilation rule of BP (e.g., *Jack live[z] in the countryside*); the remaining fourteen sentences contained thirty words followed by unvoiced consonants or pauses in which voicing of {-s} could not be the result of the BP rule (e.g., *Susan read Pam'[z] paper[z]*). In such cases, voicing of {-s} would be indicative of the acquisition of the progressive assimilation rule of English.

To investigate stress shift, twenty-one oxytone words were selected. They were produced in three contexts: isolated (e.g., *groTESQUE*), inserted in phrases with a stress clash sequence (e.g., *groTESQUE BAbies)* and inserted in phrases without a stress clash sequence (e.g., *groTESQUE deCEPtion).* To avoid the influence of the syntactic or prosodic context, the phrases were inserted in the same type of carrier sentence (e.g., *I saw ___ in the park*).

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[5] Research registered and approved by the Ethics Committee of the Institute of Psychology, University of São Paulo, under the title "Aquisição Fonológica de Segunda Língua" ('Second Language Phonological Acquisition') (CAAE 46139815.1.0000.5561).

[6] The results discussed in this article are a reanalysis of the findings of the experiments reported in Fragozo (2017). For a detailed description of each experiment, please refer to the cited study.

Finally, to check whether the learners resort to the notion of syllable weight of BP (branching rhyme) or English (branching nucleus) to stress assignment, 124 words were selected and divided into two categories: sixty words with the complex coda position filled in by plosives [p, t, k, d] in the final syllable (e.g., *absent, market, carrot, attic, basement, poniard, standard, breakfast, husband, mallard, turnip, narpek*) and 64 words with a branching nucleus (long vowel or diphthong) in the final syllable - whether or not followed by a consonant (e.g., *saloon, Portuguese, regime, fifteen, bamboo, employee*).[7]

All voice assimilation data were acoustically checked by Praat software, version 5.4.06. The cases of stress shift and stress position were analyzed perceptually, as the learners might have handled the acoustic parameters differently from the native speakers (for example, changing duration rather than pitch when assigning stress). For perceptual verification, the procedures were the same ones applied by Levey (1999) and Farias (2007): two experts in the English language identified stress assignment on each word of the corpus. After the transcriptions had been compared, in cases of disagreement, they listened to the words again until they could reach a consensus.

The data were classified using the GoldVarb-X computer software,[8] based on the Varbrul 25 package, as all of the responses are binary (e.g., voicing/non-voicing of fricatives). The nonparametric Wilcoxon test was used in the statistical analysis for comparison between two groups; - in the case of this research, the two groups relative to the age of L2 acquisition (*before the age of 12* and *after the age of 12*) and the groups of *native speakers* vs. *non-native speakers*.[9]

Results

This section reports the results found for the intersection between level of proficiency and onset age of second-language acquisition, with a focus on the significance of these two variables for the acquisition of the phonological processes addressed in this study.

In the case of *voicing,* Level of Proficiency was statistically relevant for the application of the process by Brazilian speakers; however, Onset Age of Acquisition was not statistically significant. In general, application percentage rates were very similar for speakers who started acquisition before they were twelve years old (26% of occurrences) and speakers who started acquisition after they were twelve years old (25.78% of occurrences). Table 4 shows the application rates of native and non-native speakers (in this case, considering Level of Proficiency and Onset Age), including the data whose context was followed by a voiced segment (which could allow voicing through the application of BP rule). Figure 1 illustrates a comparison of application rates among non-native speakers.

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[7] Half of the words were real words and half were logatomes, to prevent knowledge of lexical items from affecting the results.

[8] The program can be downloaded for free at: individual.utoronto.ca/tagliamonte/goldvarb.html.

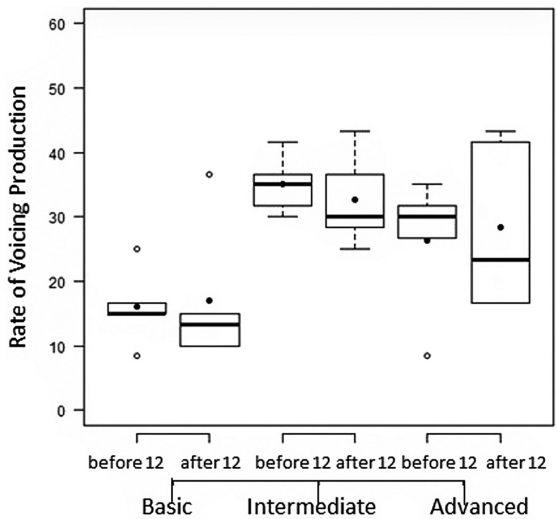
[9] The statistical analysis was conducted by Dr. Andressa Kutschenko Nahas, CONRE 9066-A.

Table 4 – Production of the fricative in all contexts

Level of Proficiency	Onset age	Voiced production	Voiceless production
Native Speakers		44.05%	55.95%
Basic	**Before 12 y/o**	16.33%	83.67%
	After 12 y/o	17%	83%
Intermediate	**Before 12 y/o**	35%	65%
	After 12 y/o	32.33%	67.67%
Advanced	**Before 12 y/o**	26.66%	73.34%
	After 12 y/o	28%	72%

Source: Authors' elaboration.

Figure 1 – Voicing by Age of Acquisition and Level of Proficiency



Source: Graphic 11 in Fragozo (2017, p.82).

At the three levels of proficiency, the average voicing rate by informants who started learning the target language before the age of twelve was higher than those who began after the age of twelve. Furthermore, the variation in voicing rate among the advanced-level speakers who started L2 acquisition after the age of twelve was greater than at the other levels.

Table 5 exhibits the rate of voicing by onset age and by level of proficiency solely for the cases of a fricative followed by a pause or a voiceless consonant, when the regressive rule of BP could not be applied. Even among the native speakers, the

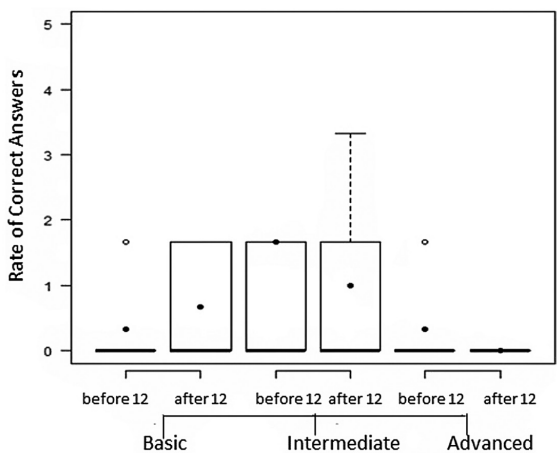
application of the rule is not categorical. In the case of non-native speakers, there were solely twelve applications of voicing in these contexts: three at the basic level, eight at the intermediate level and one at the advanced level. Figure 2 illustrates that the rule was not acquired at any of the levels of proficiency by either age group.

Table 5 – Production of fricatives when the following context has a devoiced segment or a pause

Level of Proficiency	Onset age	Voiced production	Voiceless production
Native speakers		72.85% (N = 153)	27.15%
Basic	**Before 12 y/o**	0.66% (N = 1)	99.34%
	After 12 y/o	1.33% (N = 2)	98.67%
Intermediate	**Before 12 y/o**	2% (N = 3)	98%
	After 12 y/o	1.33% (N = 2)	98.67%
Advanced	**Before 12 y/o**	0.66% (N = 1)	99.34%
	After 12 y/o	0% (N = 0)	100%

Source: Authors' elaboration.

Figure 2 – Voicing by Age of Acquisition and Level of Proficiency: following context is devoiced or there is a pause



Source: Graphic 12 in Fragozo (2017, p.83).

According to authors such as Hallé, Best and Levitt (1999), certain contrasts are very difficult to perceive and, despite a great deal of training and exposure to the target language, they continue to be processed non-natively, even in the cases of learners

whose acquisition started in childhood. According to Peperkamp (2001), the acquisition of segments, suprasegmentals, syllable structure and phonotactics in L1 occurs very early, because at one year of age, a child's perceptual capacity is already very similar to that of its parents. According to the author, although the perception of L2 can be developed by speakers who began acquisition after early childhood, having the same performance as that of a native speaker is apparently unattainable. This is in line with the findings of this research, because, contrary to expectations, not even the learners who started L2 acquisition before puberty had a minimally significant voicing rate in contexts that did not allow the application of the rule for BP.

In summary, although Level of Proficiency was indicated as statistically relevant, the process was always applied in contexts in which it could have occurred on the basis of the voicing rule in BP. Neither Level of Proficiency nor Onset Age of Acquisition had any influence on cases in which solely a progressive rule (of English) could be applied.

In the case of *stress shift*, the two variables, Level of Proficiency and Onset Age of Acquisition, were statistically relevant. As presented in Table 6, the application of the rule (in contexts with and without stress clash) was favored by informants who started acquiring the English language before the age of twelve; the speakers who started acquisition after the age of twelve, on the other hand, did not favor the application of stress shift.

Table 6 – Stress Shift by Onset Age of Acquisition

Onset age of Acquisition	Shift		No shift		Factor Weight
	N	%	N	%	
Before 12 y/o	229	33.3%	459	66.7%	0.56
After 12 y/o	167	24.2%	523	75.8%	0.43

Source: Table 33 in Fragozo (2017, p.129).

Table 7 shows the rate of shift by Level of Proficiency, Onset Age of Acquisition and Context. It can be seen that the rate of shift in the clash and non-clash phrases is quite similar both among the native speakers and the learners of the two groups: those who started acquisition before the age of twelve and those who started it after this age. In short, it does not seem to be the case that the process is being applied because of a stress clash. On the other hand, at the basic and intermediate levels, in both types of contexts (with and without stress clash) Informants who started before the age of twelve had a higher application rate (for example, in contexts with clash, basic-level informants applied shift 25.43% of the times, while those who started after they were twelve years old applied it 11.3% of the times). However, at the advanced level, the difference in onset age is no longer relevant as application rates were very similar (for contexts with clash, they were 46.08% and 46.95% in both age groups; the same difference of less than 1% was found in contexts without clash).

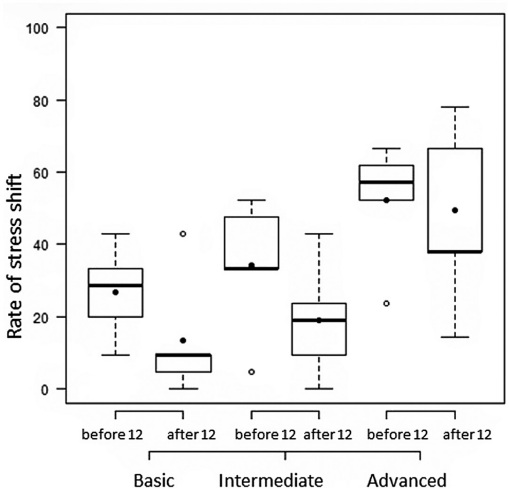
Table 7 – Stress shift by level of proficiency, onset age, and context

Level of proficiency	Onset age of Acquisition	Context			
		With clash		No clash	
		N	%	N	%
Native speaker		80	49.7%	83	51.6%
Basic	**Before 12 y/o**	29	25.43%	26	22.8%
	After 12 y/o	13	11.3%	14	12.17%
Intermediate	**Before 12 y/o**	37	32.17	38	38.66%
	After 12 y/o	20	17.39%	19	16.52%
Advanced	**Before 12 y/o**	53	46.08%	48	41.73%
	After 12 y/o	54	46.95%	47	40.86%

Source: Authors' elaboration.

Figure 3 compares the rate of shift application by native and non-native speakers, by level of proficiency and onset age in contexts with and without stress clash. The native speakers applied the process 49.4% of the times. As for the non-native speakers, at the three levels of proficiency, those who started acquisition before the age of twelve presented a higher rate of application of the rule than those who began acquisition after the age of twelve. Furthermore, the group at the advanced level that started L2 acquisition after the age of twelve is the most heterogeneous of all.

Figure 3 – Stress Shift by Onset Age of Acquisition and Level of Proficiency



Source: Graphic 22 in Fragozo (2017, p.130).

In sum, the results indicate that Level of Proficiency and Onset Age are relevant, and that the application occurs very similarly in contexts with and without stress clash.

The next analysis is focused on what happens to *stress assignment* and how it is related to syllable structure. Level of Proficiency was selected as a statistically significant variable (see Table 3), but Onset Age of Acquisition was not. In Table 8, Level of Proficiency, Onset Age, and Stress Pattern were intersected with the purpose of checking whether informants acquired the oxytone pattern, which is different in the two languages. As far as the stress patterns are concerned, for all levels of proficiency and different onset ages, there were more correct answers in the case of paroxytones/proparoxytones. When the different onset ages are considered, age solely has consequences at the basic level both for oxytones (52.66% of correct answers for beginning before twelve years of age and 48.63% for onset after twelve years of age) and for paroxytones/proparoxytones (81.27% of correct answers for beginning before the age of twelve and 66.77% when acquisition started after twelve years of age). At intermediate and advanced levels, there is no difference at the beginning of acquisition.

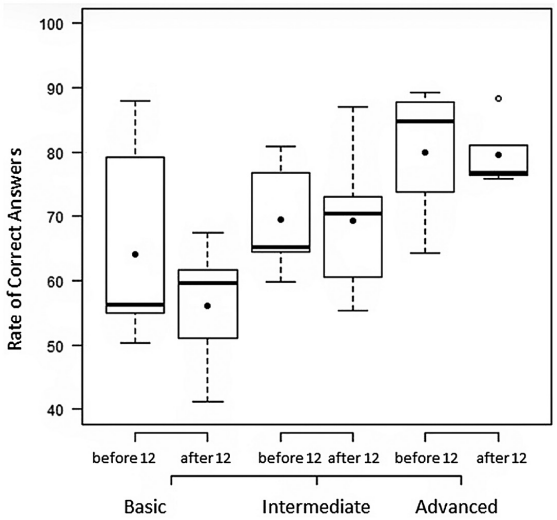
Table 8 – Stress Assignment by Level of Proficiency and Onset Age of Acquisition

Level of Proficiency	Onset Age of Acquisition	Correct answers			
		Oxytone		Paroxytone / Proparoxytone	
		N	%	N	%
Native Speaker		415/448	92.6%	385/420	91.66%
Basic	**Before 12 y/o**	168/319	52.66	243/299	81.27
	After 12 y/o	143/294	48.63	199/298	66.77
Intermediate	**Before 12 y/o**	199/314	63.37	251/298	84.22
	After 12 y/o	189/315	60	253/296	85.47
Advanced	**Before 12 y/o**	232/310	74.83	270/298	90.6
	After 12 y/o	217/301	72.09	278/299	92.97

Source: Authors' elaboration.

Figure 4 compares the rate of correct answers by Onset Age and Level of Proficiency. At the basic and intermediate levels, the informants who started acquisition before the age of twelve had a lower average of correct answers than those who started it after they were twelve years old, but there is a lot of variation in these groups. Of all the groups, the basic-level learners with onset age before twelve is the one that presented the widest variation. At the advanced level, the average number of correct answers by informants who started acquisition before the age of twelve was higher than those who started it after the age of twelve. Furthermore, the group of speakers who started acquisition after twelve years of age at the advanced level is the most homogeneous.

Figure 4 – Rate of correct stress assignment by level of proficiency and onset age of acquisition



Source: Graphic 36 in Fragozo (2017, p.193).

Basically, the results demonstrated that i) the rate of correct answers increases as the level of proficiency increases; ii) the difference at the beginning of acquisition is solely relevant at the basic level; and iii) the stress patterns have influenced the results.

Discussion

Earlier in this article, it was reported that the age factor is a widely discussed issue in L2 acquisition research, because evidence indicates that the later a learner is exposed to a second language, the more likely his/her L2 is to be affected by L1. In order to check whether onset age of acquisition could have had any influence on the learners' production in the present research, the informants were separated into two groups: speakers who started acquiring English before the age of twelve and speakers who began acquisition after the age of twelve, based on the hypothesis that the productions of learners who started L2 acquisition earlier would be more similar to the productions of native speakers, according to the Critical Period Hypothesis (LENNEBERG, 1967).

With regard to voicing assimilation, there was a tendency for speakers who started acquisition before the age of twelve to apply voicing more often at the three levels of proficiency. However, this difference was not found when considering solely the cases

in which voicing could not be influenced by the regressive rule in BP. The reason is that, as discussed previously, the rate of voicing was extremely low in these contexts. When analyzing solely rate of voicing by onset age of L2 acquisition and level of proficiency in the contexts of a fricative followed by a pause or an unvoiced consonant, when the Portuguese rule could not be applied, it can be said that the rule was not acquired by any of the groups.

With regard to stress shift, onset age of acquisition was statistically significant and indicated that the application of the rule was more frequent in the data from informants who started acquisition before the age of twelve, which would be evidence that starting L2 acquisition before puberty may actually have influenced the informants' production. This trend was observed with regard to the rates of both age groups compared to the rate of native speakers, as well as to the application of the rule by age group at each level of proficiency.

The next results to be discussed concern the age factor in the acquisition of stress assignment rules. Considering the difference in the overall rate of correct answers between the two age groups, it was found that even though the group that started the acquisition before the age of twelve had a slightly higher average percentage of correct answers, the difference between the two groups is not significant. When the two groups for onset age of acquisition are separated by level of proficiency, however, it is clear that the average rate of correct answers at the basic and intermediate levels by informants who started acquisition before the age of twelve is *lower* than the average rate of those who started after they were twelve years old. The advanced level was the only one in which the average number of correct answers by informants who started acquisition before the age of twelve was higher than those who started it after they were twelve years old. In addition, one of the differences between English and BP is that English oxytones solely occur with branching nuclei (long vowels or diphthongs, whether or not followed by consonants). In Portuguese, when there is a branching rhyme (diphthong or vowel + consonant), the accent is already oxytone. Because of this difference, Brazilians tend to produce oxytones in English as paroxytones much more often. This was exactly the result found in the present study. Even at the advanced level, paroxytones had higher rates of correct assignment than oxytones. Interestingly, this occurred even though informants had 'clues' that the final syllable was long: words with double vowels (e.g., *kangaroo, bamboo, employee, trainee, career*) also presented errors for the paroxytone pattern. In the case of the oxytone pattern, the advanced-level informants still behaved differently from the native speakers, but in the case of the paroxytone/proparoxytone pattern, their rate of correct assignment was similar to the rate of native speakers.

The results found in this research indicate, therefore, a tendency for the informants who started acquisition at a younger age to present more similar productions to those of the native speakers solely with regard to the stress shift rule. With respect to the voicing assimilation rule, the number of productions of voicing in contexts that did not allow the BP rule was so small that no generalization can be made regarding the influence

of onset age of acquisition; in brief, the rule was not acquired in any of the groups. In terms of the relation between syllable and stress assignment, at the advanced level, the productions of the informants who started L2 acquisition before the age of 12 were more similar to those of the native speakers, which corroborates the initial hypothesis formulated in this study. However, the same is not true for the basic and intermediate levels, in which, contrary to expectations, the speakers who started L2 acquisition after puberty had a higher average of correct answers.

Therefore, one cannot deny the null hypothesis that onset age of acquisition does not affect second language acquisition, since the informants who started L2 acquisition before puberty were more likely to acquire the stress shift rule at all levels of proficiency, and advanced-level speakers who started L2 acquisition before the age of 12 had a higher rate of correct assignment in the syllable-accent relation than those who began acquisition after this age. Nor can it be concluded that starting L2 acquisition before puberty is a determining factor for the acquisition of phonological rules and parameter settings because the results were not significant either for the voicing assimilation rule (which was not acquired at any level of proficiency) or for stress parameter settings. The results are very interesting in that, within the generative Principles & Parameters theory (CHOMSKY, 1981), the critical period would set the time limit when the parameters would be available for (re)setting. One must bear in mind that the non-native speakers are learning/have learned English in instructional situations, rather than immersed in the language to be acquired. They reached a rate of correct application of 70%, hence it cannot be assumed that the syllable weight parameter – responsible for stress assignment – underwent reparameterization. This result can be interpreted, alternatively, as the fact that the non-native speakers learned the orthographic rules (such as duplicate vowels) that mark the long syllable that is assigned with stress (even if this learned knowledge is not applied consistently).

Final Remarks

This study re-analyzed data from the study of Fragozo (2017) on the acquisition of three English rules by speakers of BP: fricative voicing, stress shift and stress assignment. It investigated whether the acquisition of these rules is affected by the beginning of the acquisition process - known as the critical period. The results indicated that one cannot deny the hypothesis that age affects second language acquisition, since the non-native speakers who started L2 acquisition before the age of twelve were more likely to acquire the stress shift rule at all levels of proficiency, and the advanced-level speakers who started acquisition before the age of twelve had a higher rate of correct assignment than those who started acquisition after this age, in the relation between syllable and accent. However, the present results do not allow for the conclusion that initiating L2 acquisition before puberty is a decisive factor for the acquisition of phonological rules and parameter settings because the results were not significant either

for the voice assimilation rule, which was not acquired at any level of proficiency, or for the stress parameter settings at the basic and intermediate levels. In summary, for the two phenomena that did not directly involve L1, the age factor was not relevant. In addition, the results for stress assignment may be the result of a learning strategy, because even at the advanced level, the informants demonstrated a difference in the rate of application of the oxytone and paroxytone words, exactly in the difference between the English and BP rules.

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SANTOS, R.; FRAGOZO, C. Período crítico e aquisição fonológica do inglês por falantes brasileiros. **Alfa**, São Paulo, v.64, 2020.

- *RESUMO: Este artigo trata da discussão a respeito da influência da idade de início de aquisição no processo de aprendizagem de uma língua estrangeira. Para isso, foram analisados três processos fonológicos do inglês a serem adquiridos por falantes de português brasileiro. Foram aplicados experimentos relativos ao vozeamento de fricativa em coda, retração de acento e acentuação, para informantes de três níveis de proficiência: básico, intermediário e avançado. Os resultados apontaram que, para dois dos processos (retração de acento e acentuação), o fator idade foi relevante – ao menos em determinados níveis de proficiência. Por outro lado, o vozeamento não foi adquirido por nenhum nível de proficiência, independentemente da idade de início do processo de aquisição.*

- *PALAVRAS-CHAVE: Aquisição fonológica. Inglês. Português brasileiro. Segunda língua. Período crítico.*

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