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THE PRODUCTION OF RHOTIC SOUNDS IN ONSET POSITION BY BEGINNER AND INTERMEDIATE BRAZILIAN LEARNERS

Dissertação submetida ao Programa de Pós-Graduação em Inglês da Universidade Federal de Santa Catarina para obtenção do Grau de Mestre em Letras.

Orientadora: Prof.ª Dr.ª Rosane Silveira

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Soraia Morgan

THE PRODUCTION OF RHOTIC SOUNDS IN ONSET POSITION BY BEGINNER AND INTERMEDIATE BRAZILIAN LEARNERS

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To my mother, Mairi.

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RESUMO

O presente estudo investigou a produção dos sons róticos em posição de ataque por falantes brasileiros de inglês de nível iniciante e intermediário. A pesquisa contou com 10 aprendizes de nível iniciante e 10 de nível intermediário que estudavam inglês durante o período de coleta de dados. À luz do Modelo de Aprendizagem de Fala de Flege (1995) e da Teoria da Complexidade de Larsen-Freeman (2012), três perguntas de pesquisa foram investigadas. A primeira pergunta de pesquisa explorou a hipótese dos falantes de nível intermediários obterem mais produções alvo do que os de nível básico. Os resultados mostraram que os aprendizes iniciantes tiveram mais produções não-alvo do que os intermediários, porém análises estatísticas indicaram que a diferença não foi significativa. A segunda pergunta de pesquisa gerou a hipótese de que os valores do terceiro formante do rótico que precede vogais frontais seriam mais altos do que os que precedem vogais posteriores, e essa hipótese pôde ser confirmada pelas análises estatísticas. Finalmente, a terceira pergunta de pesquisa investigou a possibilidade de aprendizes com uma Idade de Início de aprendizagem de L2 mais alta obterem mais produções não-alvo, e essa hipótese não foi confirmada. A análise acústica (valores de F3) mostraram que o retroflexo não foi sempre produzido com os valores apresentados para falantes nativos do inglês, o que indica, portanto, que há espaço para o aperfeiçoamento da produção do som-alvo, que poderia ser obtido através de instrução explícita.

Palavras-chave: rótico, retroflexo, ataque, valores de F3, Idade de Início de Aprendizagem de L2, proficiência.

ABSTRACT

The present study aimed at investigating the production of rhotic sounds in onset position by Brazilian beginner and intermediate learners of English. The research counted on 10 beginner and 10 intermediate learners studying English at the time of data collection. In the light of Flege's (1995) Speech Learning Model and Larsen-Freeman's (2012) Complexity Theory, three research questions were investigated. The first research question explored whether intermediate learners would generate more target productions than beginners. The results showed that beginners had more non-target productions than intermediate learners, however, statistical analysis indicated that the difference was not significant. The second research question generated the hypothesis that the rhotic's F3 values would be higher when produced before front vowels than before back vowels, which was confirmed by statistical analysis. Finally, the third research question investigated the possibility that learners with a higher Age of Onset would have the most non-target productions, and this hypothesis could not be confirmed. Acoustic analysis (F3 values) showed that the retroflex was not always produced with the values reported for native speakers of English, thus indicating that there is room for improvement on the production of the target sound, which could be obtained through explicit instruction.

Key words: rhotic, retroflex, onset, F3 values, Age of Onset, proficiency.

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LIST OF ABBREVIATIONS

AO	Age of onset
BP	Brazilian Portuguese
CT	Complexity Theory
EFL	English as a foreign language
L1	Native language
L2	Second language
NJ	Native Japanese Speakers
NS	Native Speakers
SLA	Second Language Acquisition
SLM	Speech Learning Model (Flege, 1995)
SP	Sensitive Period

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CHAPTER ONE - INTRODUCTION

Teachers of English as a foreign language (EFL teachers) frequently face several challenges, such as limited class time, lack of pronunciation resources in general skills textbooks and the different pronunciation problems each student might present (Foote, Holtby, & Derwing, 2011). Therefore, they need to find strategies to help minimize their students' difficulties in acquiring the English language and deal with those other problems at the same time. Thus, it is important for EFL teachers to increase their knowledge of the sound inventory of both English and their mother tongue. As a way to understand how these systems work, it is necessary to know more about Second Language Acquisition[1], particularly about how the phonological component is acquired. Over the past decades, many studies have been carried out so as to help teachers and students in what can be a long and difficult process: acquiring a second language (Flege 1995; Herschensohn & Young-Scholten, 2013; Lado, 1957; Larsen-Freeman, 2011, 2012; Zimmer, Silveira & Alves, 2009).

Brazilian learners of English face some pronunciation difficulties, especially in the early stages of their learning process. For example, they sometimes turn to epenthesis to pronounce words ending in <ed>, (Koerich, 2002; Delatorre & Koerich, 2004) and they might fail to perceive and produce syllable-final nasals in English (Kluge, 2004). Another problem they usually face is the production of rhotic sounds (Osborne, 2008; Schadech, 2013). For instance, they may pronounce a word like "rose" [ɹoʊz] as [hoʊz] "hose", which may even cause a funny situation or/and miscommunication. For example, if somebody says: "Look, I have brought you *hoses*" [ˈhoʊzɪz], instead of *roses* [ˈɹoʊzɪz]. Once again, it is something that happens mainly in the first stages of the learning process, when Brazilian learners tend to transfer the rhotic sounds from their native language (L1) to English (Osborne, 2008).

Based on the discussion above, the present study aims to investigate the production of the rhotic sounds in onset position by beginner and intermediate Brazilian learners of English. Previous studies with Brazilian students of English have been carried out (e.g.,

[1] In the present study, I use the term *Second Language Acquisition* to refer to any language acquired subsequent to the first one. Moreover, the terms *L1*, *native language*, *mother tongue*, and *first language* might be used interchangeably, as well as the terms *foreign language*, *L2* and *second language*.

Deus, 2009; Osborne, 2010; Schadech, 2013), but none investigating solely the production of the rhotic in absolute onset. Therefore, an analysis of the rhotic sounds in Brazilian Portuguese and in English will be carried out departing from the principles proposed in Flege's (1995) Speech Learning Model (SLM), and Complexity Theory (Larsen-Freeman, 2012) to be described later in this text. Within the SLM, the process of L1 transfer will be investigated in order to provide some explanation as to why, when and how it takes place with the rhotic sounds.

1.1. CONTEXT OF INVESTIGATION

As an English teacher to Brazilian students for over 10 years, I have always observed the difficulty some students have in producing certain English sounds, such as [t], or perceiving the difference between [i] and [I], or still the production of "s" clusters, as in the word "street" /strit/. As a consequence of such difficulty, there are many situations in which students cannot get their point across when communicating to classmates, to teachers, to native speakers of English, and to users of English as an intermediate language. Therefore, I have always been interested in being able to give appropriate instructions to my students so that they could reach a pronunciation level that allowed them to make themselves understood. That is the main motivation for this research.

The problem to be investigated in the present study is one of the English consonants that Brazilian students usually have difficulties pronouncing: the orthographic "r", or rhotic. Non-target pronunciation of rhotics may cause miscommunication and even funny situations, as already mentioned in the introduction. For example, a sentence like *"I am going to **ride** a horse"* may sound like *"I am going to **hide** a horse"* if the speaker fails to produce a distinction between the retroflex liquid in the beginning of "ride" and the glottal fricative in the beginning of "hide". The word "hide" in the second sentence would be an attempt to say "ride", and we could say that there might have been transfer of the Portuguese sound [h][2] for the orthographic "r", which is pronounced as a retroflex [ɹ] in English.

[2] The rhotic sounds of Brazilian Portuguese will be presented in section 2.4.2.

1.2. SIGNIFICANCE OF THE RESEARCH

Although there have been studies on the production of English rhotic sounds by Brazilian Portuguese speakers of English (e.g., Osborne, 2008, 2010, Deus, 2009, Schadech, 2013), L2 phonology studies still lack a solid contribution of acoustic analysis to describe the nature of L2 sounds. This study will include auditory and acoustic analysis of data. Moreover, the role of proficiency and participants' profiles need to be taken into account in order to understand the development of L2 phonology, as many studies have disregarded these variables. A better understanding of the rhotic sounds in Brazilian Portuguese/American English interphonology will provide EFL teachers with more knowledge to minimize their students' difficulties in producing them. By understanding the difference in the production of rhotic sounds across levels and how individual differences influence this process, EFL teachers might be able to fashion new techniques and exercises to teach these sounds in the EFL classroom from the basic levels.

This study is going to be divided into five chapters: after this introduction, chapter two brings the review of literature; chapter three describes the method used for this research; chapter four is an account of the analysis of the data collected by the researcher; and chapter five presents the conclusions drawn from data analysis, in the light of the literature to be presented in the next chapter.

CHAPTER TWO - REVIEW OF LITERATURE

This section begins with some important literature on L1 transfer and its implications on communication, followed by a description of Flege's Speech Learning Model's most relevant hypotheses for this study and a summary of Complexity Theory. Then, studies on the role of proficiency on L2 pronunciation will be introduced. Next, some previous studies on rhotics are presented, and finally there is a description of the rhotic sounds in English and in Brazilian Portuguese. The research questions and hypotheses guiding this study are presented at the end of this chapter.

2.1 THE SPEECH LEARNING MODEL AND L1 TRANSFER

Flege's Speech Learning Model (1995) attempts to explain why achieving accurate pronunciation in an L2 is more probable when the age of onset is low. Moreover, it assumes that the production and perception of vowels and consonants can change as the learner progresses, adding some features and adapting others. The model presents several empirical studies that could help explain the causes of foreign accent in L2 production. As mentioned above, one of the main factors investigated is age of onset. The SLM also describes studies that deal with perception and production of vowels, word-initial and word-final consonants. Its focus is on phonemes, rather than suprasegmental features of speech (e.g. intonation, stress), and although it mentions studies in other L2, English is the most investigated language.

As shown by the studies of Gass and Selinker (1994, p. 53), Major (1994), Flege (1995) and Baptista (2002), students of any given foreign language tend to transfer aspects of their L1 into the L2. Such transfer may hinder intelligibility[3], even for listeners who share the same L1 with the speaker (Schadech, 2013). Moreover, pronouncing words unintelligibly might bring unwanted consequences to a L2 user in many different situations – ordering food in a restaurant, trying to buy airplane tickets, getting to know a person, asking for directions, etc. However, the present research is not going to assess intelligibility on the perceptual dimension, rather the focus will be on the production of segments.

[3] According to Munro, Derwing, & Morton (2006), intelligibility is what listeners understand from speakers' speech.

Besides applying the sound inventory of the L1 to the L2 (L1 transfer), there is also an indication that non-native speakers do not perceive L2 sounds the same way monolingual native speakers do. The Speech Learning Model (SLM – Flege, 1995) predicts that non-natives do not perceive some phonetic differences in the L2 and that L2 sounds that do not exist in the L1 may be produced more accurately than L2 sounds present in the L1. This would happen because the former would be treated as "new" and therefore, a new category would be created in the sound inventory, whereas the latter are treated as "similar" and may generate pronunciation problems stemming from L1 transfer (Flege, 1988b, as cited in Flege, 1995). Similarly, Major (2001) hypothesizes that phones that are perceptually less similar in the L2 will be perceived by speakers better than perceptually more similar ones.

One of the factors that could hinder the creation of a new category in the L2 for sounds that do not exist in the L1 and therefore, be a constraint in L2 acquisition, is age of onset (AO). Granena and Long (2013) claim that, according to research, it is very rare for a learner who has an AO beyond 12 to achieve native-like pronunciation. In their study, conducted with 65 Chinese learners of Spanish, no participant with an AO higher than 5 achieved native-like pronunciation. Beyond a certain AO, L2 learners tend to use the L1 sound system to interpret and represent sounds in the L2, and that happens not only for similar sounds but for sounds that are considered "new" as well (Flege, 1995). Flege, Munro and Mackay (1995) conducted a study with 240 Native Italian learners of English, with different AO. They found that the production of "r" (a retroflex in English), which is a trill in Italian, was accurate for subjects with an AO before 10 years of age, whereas for those subjects which had an AO higher than 10, the accurate production rates dropped abruptly.

The SLM also predicts that the probability of a learner distinguishing the phonetic differences between sounds of the L1 and the L2 decreases as AO increases. It is also less likely that sounds in the L2 that are not contrastive[4] in the L1 be distinguished as AO increases.

[4] Sounds that are in contrastive distribution are those that occur in the same environment, such as [ɹ] and [l] in English: "more" and "mole", and which distinguish words. Sounds that are in complementary distribution are those that never appear in the same environment, that is, the presence of one excludes the presence of the other, and they do not distinguish words. In English, we can say that the dental nasal [n̪] and the alveolar nasal [n] are in complementary

Flege (1995) provides support to that hypothesis by saying that it is easier for native Japanese (NJ) learners of English to produce and make a distinction between English liquids in word-final than in word-initial position (Strange, 1992, as cited in Flege 1995). A possible explanation for that would be that, according to Sheldon and Strange (1982, as cited in Flege, 1995), the difference between English liquids is bigger in final than in initial position. Therefore, as AO increases, less salient sounds are less likely to be perceived.

Still according to the SLM, if L2 speakers identify an L2 sound with an L1 sound, they will replace the L2 sound with the L1 sound, even if those sounds are phonetically different. Moreover, contrasts in the L2 that are not present in the L1 will not be acknowledged. An example of that in Brazilian Portuguese would be the contrast between the English vowels /i/ and /I/, which does not exist in Brazilian Portuguese. Contrarily, contrasts in the L1 that do not exist in the L2 might be produced in the L2, for instance, the nasal vowels of the Portuguese language which are not present in the English language.

It is important to mention that, despite all the data that supports the existence of a critical period hypothesis, some researchers deny it, using as evidence the identification of older learners who achieve native-like competence in L2 (Epstein, Flynn & Martohardjono, 1996). Moreover, there are some early learners who, even being exposed to the language in an L2 environment, still present some level of foreign accent. Furthermore, amount of second language education is a factor that should be taken into consideration as a predictor of second language acquisition as well (Flege et al, 1999).

For the purposes of this study, however, I will consider what the SLM concludes and that is nowadays well accepted across SLA theories: the earlier, the better. According to Long (1990) there are sensitive periods for phonological acquisition of an L2 that close around age 12. There is still need for further research to understand exactly why that happens, but AO seems to play a very import role in the production of L2 sounds. Therefore, the relationship between onset of learning and accurate production of L2 sounds is one of the aspects to be investigated by the present study.

Inasmuch as the present study is going to be conducted in the light of Flege's Speech Learning Model, this section has presented a

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distribution (Yavas, 2011). The first one occurs only before [t] and [d] and the second one never appears before these segments.

brief explanation of the framework, as well as the concept of L1 transfer.

2.2 COMPLEXITY THEORY

This section provides a brief overview of Complexity Theory (henceforth CT) and its main aspects.

Taking into account that SLA is psycholinguistic rather than just linguistic (Larsen-Freeman, 2011) CT posits that language development is dynamic and open, different from early language acquisition theories, such as Universal Grammar (Chomsky, 1957), which view language as innate and stable. Because it is an open system, it is in constant interaction with the environment and through it learners receive feedback and then adapt what they already know in order to construct new knowledge.

An important aspect of CT is *organized complexity* or, as Larsen-Freeman (2012) defines it: "parts work together to produce a coherent structure from their interaction, such as with individual birds coming together to form a flock." (Larsen-freeman, 2012, p.74). Taking on this holistic approach, which considers the physical, social, cognitive and cultural aspects of language acquisition, CT views SLA as *emergent*, meaning that form arises from usage (Larsen-Freeman, 2012). Therefore, according to CT, language is always being constructed and adapted and learners' productions are a result of how they use it (Larsen-Freeman, 2012). In order to make room for the new information received, which might compete with old information, the brain must make new connections and adapt (Holme, 2013).

Another element present in CT is the *butterfly effect*, or "the fact that even the smallest of differences can have a huge, amplifying effect on the subsequent behavior of the system" (Larsen-Freeman, 2012, p.75). In SLA, we could say that every single individual factor - motivation, AO, L1 and L1 dialect, exposure to the L2, trips to places where the L2 is spoken, readings, etc - might make a difference in the acquisition of the L2. However, since it is not a simple task to measure those individual factors, it is difficult to predict their effect.

CT also predicts what it calls the *soft assembly* of language resources. What it means is that learners interact with other speakers using the components of the system that they already have, while adapting, in real time, to fit the new information received. It is called "soft" because the elements being built and incorporated may change at any point during the task. (Larsen-Freeman, 2012). Larsen-Freeman

(2011, 2012) also claims that, by repeatedly soft assembling these elements, especially those that are salient and semantically transparent, they become emergent in a complex system through imitation.

The process of imitation is not exact, but rather adapted to the speaker´s needs. So it does not necessarily mean that received input equals produced output, but rather, that learners merge old and new forms and build new ones, which later become available for use and supplementary changes (Larsen-Freeman, 2011). It is also worth noting that learners tend to use forms that are similar to the L1 (Larsen-Freeman, 2012) and seem to have an emotional connection to some patterns over others (Todeva, 2009, cited in Larsen-Freeman, 2012).

In sum, CT views language as a complex process, marked by continuous change. It claims that form is a result of language use. Therefore, in order for a structure in the L2 to be acquired, it must adapt to the cognitive system through interaction. Even the smallest of individual characteristics may generate different results in the acquisition of the L2, and adapted imitation plays an important role, with learners merging old and new forms to constitute L2 output.

2.3 STUDIES ON THE AGE FACTOR

This section is going to report some relavant studies conducted in the past decades regarding the age factor in second language acquisition.

An early study by Johnson and Newport (1989) attempted to test the critical period hypothesis for second language acquisition. The authors investigated 46 native speakers of Chinese and Korean who had arrived in the USA between 3 and 39 years of age and had been living in the country from 3-26 years at the time of the study. They applied a series of grammar tests and found that the speakers who had arrived in the country at an earlier age performed better than those who arrived at an older age. However, after puberty, although the performance was low, it was variable and not related to the age of arrival. Nevertheless, the authors claim that the critical period hypothesis could be supported by the results of their study.

Moyer (2004) cites various studies conducted on the age factor. Hoefnagel-Höhle (1982, as cited in Moyer, 2004) found that older children (12-15) and adults had better results in pronunciation tests than younger children (8-10). Later investigations with different age groups confirmed the results : 3-5 year-olds had the lowest scores while 12-15 year-olds acquired pronunciation, morphology, syntactic judgements, and listening comprehension faster than other groups. Moyer (2004)

emphasizes that such results indicate that older learners may attain as much as younger learners.

Another study cited by Moyer (2004) indicates that older learners outperform younger learners in morphological and syntactic tasks, while the latter develop better phonological skills (Fathman, 1975, as cited in Moyer, 2004). Older learners also presented higher scores than younger learners in various tasks such as reading, writing, listening comprehension and speaking in a study by Ekstrand (1976, as cited in Moyer, 2004).

Moyer (2004) also cites Krashen et al. (1982), saying the authors come to the conclusion that studies until then had found that " (1) adults and older children show advantages over young children in rate of learning, especially in the areas of syntax and morphology; and (2) earlier exposure generally indicates higher proficiency. " (Moyer, 2004, p. 16).

A very recent study, conducted by Lima (2015), investigated whether there is an influence of the age factor on the acquisition of English vowels among Brazilian students who began their English courses at different ages. The author hypothesized that the higher the AO, the greater the effects of L1 phonology would be on the L2. The study counted on 30 advanced students who had never lived abroad and who were divided into three groups: those with an AO lower than 12, those with an AO between 12 and 14, and those with an AO higher than 16. Besides the Brazilian speakers, 10 native speakers of American English composed a control group.

The author confirmed the hypothesis: the higher the AO, the harder it was for the speakers to acquire the target vowels in the L2. However, the age factor was not determining of acquisition, insofar as even the group of the youngest learners had a very different production from that of the control group.

Saito (2015) investigated whether age of acquisition can influence L2 oral proficiency after puberty. The participants were 88 experienced Japanese learners of English and 40 baseline speakers (inexperienced Japanese speakers and native English speakers). The author found that the higher the age of acquisition, the worse participants did on accentedness and comprehensibility tests, showing relatively strong age effects on segmental and prosodic attainment. However, fluency and lexicogrammar attainment were not influenced by age of acquisition. The authors conclude that rather than confirm the critical period hypothesis, the results support that both young and adult learners may be able to attain and improve L2 proficiency when higly

motived and given the proper opportunities (Flege & Liu, 2001, as cited in Saito, 2015).

The aforementioned studies show that there is still much controversy on a critical (or sensitive) period for second language acquisition. However, it could be said that early learners usually outperform late learners in phonology, although that is not a rule.

2.4 RHOTICS

This section will start by defining the term "rhotic". Second, it presents a description of the use of rhotic variants in English and an acoustic description of the English retroflex. Then, there is an acoustic description of the fricative. Next, the distribution of the rhotic in BP will be described. Finally, the research questions and hypothesis of the present research will be presented.

Different from most phonetic categories, which are defined by articulatory and auditory properties of sounds, the terms rhotics or r-sounds are used as so because the sounds that integrate this category tend to be written with the same Greco-Roman letter ("r") or its Greek counterpart rho. (Ladefoged & Maddieson, 1996).

Ladefoged and Maddieson (1996) also state that rhotics have similarities with vowels and that vowel sounds before rhotics tend to be longer and also "colored". Vowel coloring occurs when a vowel is followed by 'r' in the same syllable, and in that case, the contrast between vowels is lost. For instance, the high front vowels in "ear", "fear", and "pier" have almost the same pronunciation, they do not resemble either /i/ nor /I/, but are somewhere in between the pronunciation of those two sounds. The same happens to the high back vowels in "endure", "poor", and "mature", (Yavas, 2011, p. 81)

According to Ladefoged and Maddieson (1996), rhotic sounds are very common in the languages of the world: 75% of them use some production of rhotics. Most of those languages containing rhotics use some form of trill, and 18% of them have two or three different types of "r" (Ladefoged & Maddieson, 1996).

2.4.1 A description of the Rhotic Sounds in English

In the following paragraphs, the rhotic sounds will be described mainly in American English, but some other English varieties will also be mentioned.

Across English speaking countries, it is possible to find "rhotic" and "non-rhotic" English accents. In the former, "r" is pronounced wherever it occurs in the spelling, whereas in the latter it is pronounced only before a vowel. Countries with rhotic accents include: the USA, Canada, Scotland, Ireland, much of the Caribbean, and some regions in the West of England. Non-rhotic varieties can be found in most of England and Wales, most of the American English spoken in the Southern and Eastern states, some Caribbean, all Australian, all South African, and most New Zealand varieties (Ladefoged & Maddieson, 1996).

Yavas (2011) states that the most common realization of "r" in English is the retroflex approximant [ɹ], and that it "is produced with the tip of the tongue curled back toward the hard palate" (p. 69). The retroflex pronunciation of the orthographic "r" in General American English is found in all positions within a word: "restaurant" [ˈɹɛstəɹɪənt], "door" [dɔɹ], "dream" [dɹim].

Delattre and Freeman (1968, as cited in Ladefoged & Maddieson, 1996) also affirm that the retroflex is the main production of "r" in English, and they add that it is produced with "a constriction in the lower pharynx, as well as lip rounding (p 234)". However, Yavas (2011) states that the approximant is not the only possible production of the rhotic, and some Americans prefer to pronounce "r" with no retroflexion, which results in the so called "bunched r".

Ladefoged and Maddieson (1996) explain that English speakers in the South of England produce the prevocalic rhotic as an alveolar approximant. Because of the non-rhotic quality of most of British English, its speakers will delete the postvocalic "r", as in the word "car" – [kɑː] (Collins & Mees, 2013). Some urban South African English dialects have the alveolar fricative as their preferred rhotic pronunciation. In the Northwest of England and in Sierra Leone, uvular rhotics are present. In the Scottish English spoken in cities like Edinburgh and Glasgow, the tap is the most common realization of "r". The trill is only used in some cities in the Lowlands, despite its being used as standard Scottish accent for comic purposes (Ladefoged & Maddieson, 1996). Cruttenden (2008) adds that the tap occurs mostly in onset position and the retroflex is the preferred and also more prestigious variant of the rhotic in Scotland.

A study by Foulkes and Docherty (2000) calls attention to a change in rhotic production in England, attributed by them to the process of accent levelling. The authors looked into the production of "r" in the cities of Derby and Newscastle and found that the variant [ʋ]

(labiodental approximant) is being used in place of [ɹ] especially by younger people. The study shows that using [ʋ] instead of [ɹ] has been considered a speech defect, a production used by children acquiring the English language, before they can produce [ɹ] and it was also used by noble people. It is still not rare to encounter examples of the variant being used by comedians for humorous purposes. However, according to data collected by the authors, more and more young and middle class speakers are adopting it.

Based on the above information, it is possible to say that although there is presence of other types of rhotics in English, the retroflex approximant is its most common realization across countries, and especially in the United States. Thus, it will be considered the target pronunciation of the rhotic sound in onset position in the present study.

2.4.1.1 Acoustic description of the retroflex in English

One of the most important studies carried out to date on the acoustic description of rhotic sounds was the one by Lehiste (1962). When describing the rhotics, the author affirms that besides the low frequency of the third formant, there is a short distance between F2 and F3. Furthermore, the author suggests that there is a small influence of the following vowel on the rhotic, because the transition from the initial "r" to the vowel is very fast. She adds that the vowels preceded by initial /r/ may present F3 values 100Hz higher than those that are the nucleus of consonant-nucleus-consonant sequences. Therefore, she concludes that there is a small influence of /r/ on the following vowel.

Ladefoged (2003) states that the retroflex approximant has visible formants and that its F3 usually presents low values. Variations on the F3 frequency indicate the degree of rhoticity of the variant: the lower the F3, the higher the degree of rhoticity (Ladefoged, 2003, p.149). For example, in the sequence "a red berry", the F3 value in "red" is 1,240Hz, which indicates a high degree of rhoticity. In the word "berry", on the other hand, the rhotic is in intervocalic position and, therefore, F3 goes up to 2,100Hz.

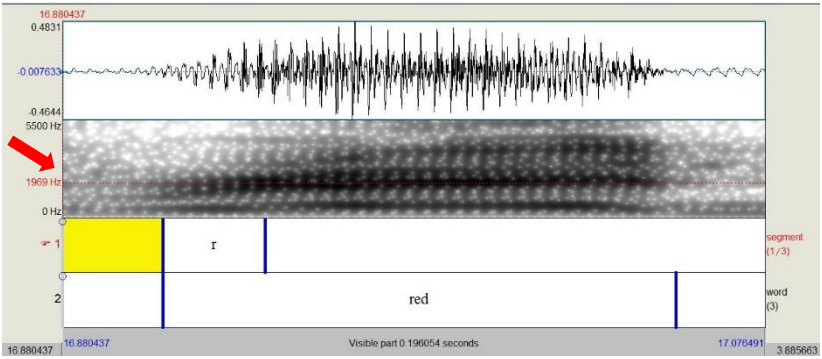
The author explains that such difference is due to the great movement of the tongue made to produce the rhotic in onset position in a stressed syllable, in the case of the word "red". However, in the word "berry", the movement is not so great, thus raising the F3 value. The bigger the raising of the tongue and the retroflexion movement, the lower the F3 values. Ladefoged and Maddieson (1996) also affirm that

the retroflex presents a very low frequency of the third formant, below 2,000Hz, and sometimes as low as 1,500Hz.

Lawson, Stuart-Smith, Scobbie and Maclagan (2011) also claim that the approximant presents transitions of formants in and out of a steady period, whose duration varies according to factors such as the position of the rhotic in the word, for instance. In order to illustrate the acoustic features of the English rhotics, some tokens produced by one female and one male NS of English have been selected from the Speech Accent Archive (Weinberger, 2015) to obtain spectrograms using PRAAT.

In Figure 1 it is possible to see the three first formants of the retroflex variant in onset position, produced by a female speaker. The first formant has a value of 603Hz, the second, 1,286Hz, and the third 1,969Hz - as shown by the red dotted line in the figure, indicated by the red arrow. Those values are in accordance with the literature which states that the second and the third formant are very close in value, and that the third formant is below 2,000Hz. It is also important to note how the transition from the rhotic to the following vowel is difficult to perceive in the spectrogram. In this case, the auditory analysis also aids segmentation.

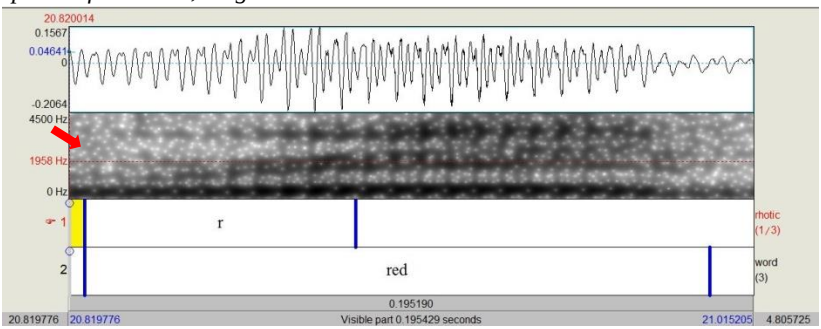
Figure 1 - *The word /ɹɛd/ produced by a 21 year-old female native English speaker from Richmond, Virginia.*



Retrieved from The Speech Accent Archive at http://accent.gmu.edu/.

Very similar to Figure 1, Figure 2 displays the rhotic in onset position in the word /ɹɛd/, now produced by a male speaker. F1, F2 and F3 values are, respectively, 414Hz, 1,375Hz, and 1,958Hz – as shown by the red dotted line in the figure, indicated by the red arrow. Once again, the transition from one segment to another is difficult to visualize, and the auditory analysis is therefore crucial when segmenting the word.

Figure 2 - *The word /ɹɛd/ being produced by a 21 year old male native English speaker from Wise, Virginia.*



Retrieved from The Speech Accent Archive at http://accent.gmu.edu/.

2.4.1.2 Acoustic description of the glottal fricative in English

The glottal fricative [h] in English is described by Ladefoged (2001, p. 57) as "turbulence – the random variations in air pressure – caused by the movement of the air across the edges of the open vocal folds and other surfaces of the vocal tract. Because the principal origin of the sound is deep within the vocal tract, rather than near the lips or the front of the mouth, the resonances of the whole vocal tract will be more prominent, and the sound is more like that of a noisy vowel."

The author exemplifies the frequency of F3 in the word "high", which is a little below 3,000Hz. And he concludes by saying that the consonant [h] presents the noisy forms of the formants of adjacent vowels.

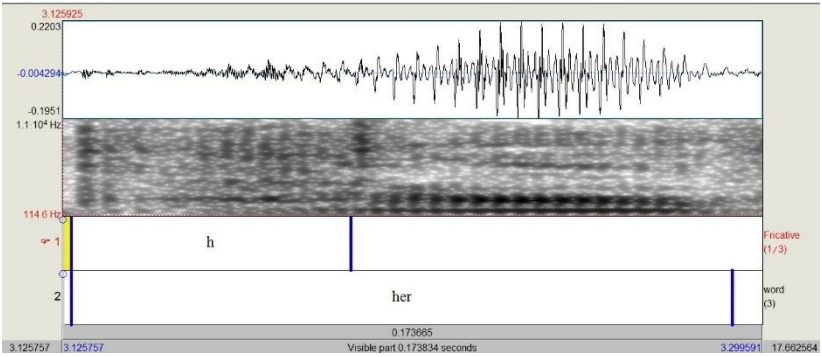
Yavas (2011) states that the English language has nine fricative phonemes, one of them is the voiceless glottal fricative /h/. Cruttenden (2008) affirms that the velar fricative is common only in the pronunciation of some Scottish speakers, as in the word *loch* [lAx]. Yavas (2011) explains that the voiceless glottal fricative has a defective distribution because it can only appear in syllable-initial position, as in "home" [hoʊm] and in "his" [hIz]. However, it is pronounced with a breathy voice when in between vowels, as in "ahead", "behind", "behave".

As for the distribution of the glottal fricative /h/, it appears only in syllable-initial, prevocalic positions, such as in word-initial (*heat, hen, hot, who, etc*) and in word-medial (*ahead, behave, behind, anyhow, etc*) (Cruttenden, 2008). In words such as *"hour", "honest", "exhaust", and "vehicle"*, the "h" is silent.

Machač and Skarnitzl (2009) consider the voiced fricative [ɦ] a vowel pronounced with a creeky voice. Therefore, they affirm that it is difficult to establish the exact transition point to the following vowel, which makes segmenting more challenging. However, in the waveform of the fricative, there is greater presence of noise than in the vowel's. It is possible, thus, to see a spiky waveform with aperiodic noise in the central portion of the fricative (Machač & Skarnitzl, 2009).

In Figure 3, it is possible to see the waveform and spectrogram of the word "her" being produced by an American female speaker (speech archive data). As mentioned above, the central part of the fricative has greater presence of noise, which might be visible in the spectrogram, but sometimes it is also hard to locate it. The noise would be indicated by darker portions in the spectrogram. A spiky waveform and the aperiodic noise can also be considered characteristics of a fricative variant.

Figure 3 - *The word /hɜ˞/ being produced by a 21 year old female native English speaker from Richmond, Virginia.*



Retrieved from The Speech Accent Archive at http://accent.gmu.edu/.

Machač and Skarnitzl (2009) also claim that it is common for a lenition process to occur with the fricative [ɦ]. That way, the variant loses its friction and becomes more like an approximant. Another tip given by the authors to establish the transition from the fricative to the vowel is to observe the relative intensity of F4 and F5. They say that a high frequency intensity is more likely to occur in voiced consonants than in the adjacent vowels. Since it is very difficult to distinguish the fricative from the adjacent vowel only by looking at the waveform, the tip for segmenting is to look at the differences in relative intensity, happening at around 4,000Hz. One last recommendation is to look for a simpler waveform, which would be related to the sonorant character of

the fricative. The complexity of the waveform of the fricative aids segmentation.

2.4.2 A description of the rhotic sounds in Brazilian Portuguese

This section will begin with a description of the rhotic sounds in Brazilian Portuguese, according to Cristófaro-Silva (2010). Since the author focuses mainly on the production of rhotics in the cities of Rio de Janeiro and Belo Horizonte, and on the so-called "caipira r"[5], other studies will be mentioned below to show how rhotics are realized in the South region of the country. Next, a brief acoustic description of Brazilian rhotic sounds will be given.

Cristófaro-Silva (2010) states that in Brazilian Portuguese, rhotics can be divided into two types: the "strong R" and the "weak r". The latter refers to the tap, which is represented by the phoneme /ɾ/ and it appears in all dialects in the country between vowels (*caro* – "expensive") and preceded by a consonant in the same syllable (*prata* – "silver"). Besides also occurring in intervocalic position (*marrom* – "brown"), the "strong R" appears in onset in the beginning of a word (*rua* – "street"), and in onset preceded by a consonant (Israel – "Israel"). The production of the "strong R" can vary across dialects, but mostly, it is realized as a velar fricative [X], a glottal fricative [h] or as a trill [ř].

Still according to Cristófaro-Silva (2010), there is contrastive distribution of the "strong R" and the "weak r" only in intervocalic position: *caro* ("expensive")/*carro* ("car"). However, in some communities, especially in the South of the country, which have been colonized by Italian, German and other European immigrants, such contrast is not observed (Battisti & Martins, 2011). Therefore, in those places, words like *carro* ("car") and *caro* ("expensive") are homophones [k͡ˈaɾʊ].

Cristófaro-Silva states that the "weak r", as mentioned above, occurs in intervocalic position and following a consonant in the same

[5] The author considers "caipira r" the production of "r" as a retroflex, which occurs in some regions in the state of Minas Gerais. However, according to Brandão (2007, as cited in Rennicke, 2011), the retroflex production of "r" also occurs in the states of Rio Grande do Sul, Santa Catarina, Paraná, São Paulo, Mato Grosso do Sul, Rio de Janeiro, Minas Gerais, Goiânia, Mato Grosso, Bahia, Sergipe, Tocantins, Pará and Paraíba. Data from VARSUL points to its presence in all three southern states, but also shows that it is more common in Paraná.

syllable and its realization is the tap [ɾ] in all dialects of the Brazilian Portuguese language. As for the "strong R", it is distributed as follows:

- in intervocalic position (*murro* – "punch"), in the beginning of a word (*rato* – "rat"), and following a consonant in a different syllable (*enredo* – "plot"), it is realized as a voiceless glottal fricative [h] in Belo Horizonte, as a voiceless velar fricative [X] in Rio de Janeiro, and as a trill [ř] in the *caipira* dialect;
- in coda, before a voiced consonant (*corda* – "rope"), it is produced as a voiced glottal fricative [ɦ] in Belo Horizonte, a voiced velar fricative [ɣ] in Rio de Janeiro, and as a retroflex [ɹ] in the *caipira* accent;
- in coda before a voiceless consonant (*torto* – "askew"), and in word-final position (*mar* – "sea"), it is realized as a voiceless glottal fricative [h] in Belo Horizonte, as a voiceless velar fricative [X] in Rio de Janeiro, and as a retroflex [ɹ] in the *caipira* accent.

Analyzing the aforementioned distribution, the author concludes that the contexts in which free variation of rhotics can occur in Brazilian Portuguese are restricted. According to her, the sounds [X, ɣ, h, ɦ] can occur in free variation in intervocalic position, word initial, word final, and in onset position preceded by a consonant. Therefore, the following words may be produced as follows, depending on the region of the country:

- *Carro* ("car") - [ˈkaXʊ], [ˈkaɣʊ], [ˈkahʊ] or [ˈkaɦʊ]
- *Rato* ("rat") – [ˈXatʊ], [ˈɣatʊ], [ˈhatʊ] or [ˈɦatʊ]
- *Mar* ("sea") – [maX], [maɣ], [mah] or [maɦ]
- *Israel* ("Israel") – [iʃXaˈɛw] or [ishaˈɛw]

On the other hand, in syllable limit, the rhotic variant will depend on the following consonant. When "r" is followed by a voiceless consonant, the rhotic will be realized either as [X] or [h]: *torto* ("askew") – [ˈtoXtʊ] or [ˈtohtʊ], and when it is followed by a voiced consonant, it will be realized either as [ɣ] or [ɦ]: *larga* ("wide") – [ˈlaɣgə] or [ˈlaɦgə].

The VARSUL[6] project collected data from 1988 to 1996 in twelve cities in the states of Santa Catarina, Rio Grande do Sul, and Paraná. One of the main objectives of the study was to determine

[6] Variação Linguística do Sul do Brasil – www.varsul.org.br

linguistic variation in those three states. An overall look at all of the data collected by VARSUL shows that in most cities, in onset, the trill and the fricative are the most common variants of "r" and the tap is the favorite one in coda. The velar fricative is the preferred production in capitals, except in Curitiba. Therefore, it could be stated that "r" production is conditioned by syllable position and geographical group.

Monaretto (2002, as cited in Brescanscini & Monaretto, 2008) shows that in Porto Alegre, there is an ongoing change concerning rhotic realization, and the front "r" (the trill) is moving back (velar fricative). In post-vocalic position, the tap is giving place to deletion. In pre-vocalic position, front variants of the rhotic are being kept due to social and ethnic identity, (Rigatti, 2003, Silveira, 2008 as cited in Brescanscini & Monaretto, 2008).

Yet another study carried out by Silva (2008) with four speakers from Florianópolis (Santa Catarina), revealed that in coda position rhotics tend to be deleted (47%) or pronounced mainly as voiceless glottal fricatives (34%).

As shown in Cristófaro-Silva (2010) and in the studies mentioned above, the realization of the rhotics can vary to a great extent, depending on syllable position and region of the country. However, it is possible to say that, considering the cities of Rio de Janeiro, Belo Horizonte, the twelve cities included in the VARSUL project, the glottal and velar fricatives are the most common realizations in coda, especially in capital cities, followed by the tap and the retroflex. Although the studies focused mainly on the rhotic in coda, researchers who used data from VARSUL investigated its possible realizations in onset too, and it could be concluded that, in the southern states, the velar fricative is the most common realization, followed by the trill (Brescanscini & Monaretto, 2008).

2.4.2.1 Acoustic Description of the Rhotics in BP

Not many studies are dedicated to the acoustic description of the rhotics in Brazilian Portuguese. Therefore, below there is a brief summary of the acoustic characteristics of some rhotic variants in Brazilian Portuguese, as described in Barbosa and Madureira (2015).

Barbosa & Madureira (2015) first describe the rhotic according to the realizations of Brazilian and Portuguese speakers. Since the present study deals with the pronunciation of Brazilian speakers, I will include the book's acoustic description of the rhotic as realized by the Brazilian speakers only.

The first Brazilian speaker is from the state of Minas Gerais. The authors describe the rhotic in the word “caro” as being produced as a tap with two important features: F2 is raised at the right margin of the preceding vowel, and the segment is marked by a short sudden energy drop. In complex onset position, Barbosa & Madureira (2015) investigate the words *prata* (“silver”) and *preta* (“black”). In that position, the rhotic is mostly realized as a tap as well. Formant values preceding the tap are much higher before the vowel “e” than before the vowel “a”, and there is also a much faster transition to the vowel’s F2 passage. For the speaker from Minas Gerais, the tap’s F2 value is 1,315Hz for the word “prata” and 1,498Hz for the word “preta”.

For the analysis of the rhotic in coda position, Barbosa & Madureira (2015) counted on three female Brazilian speakers from São Paulo, Minas Gerais and Pará. The participants from Minas Gerais and from Pará produced a voiced velar fricative. For the participant from Minas Gerais, in the word *carta* (“letter”), the vowel F1 and F2 values are around 900Hz and 1,900Hz, respectively. Moreover, because of the coarticulation, the fricative’s F2 and F3 values are around the same values of the stressed vowel’s F2 and F3. For the speaker from Pará, there are no formants under 1,000Hz. The authors claim that because the fricative is realized with a much shorter duration than that of the speaker from Minas Gerais, determining the point of articulation is not so easy, although it does not sound like a glottal sound, therefore, they conclude it is a velar fricative.

Barbosa & Madureira (2015) also investigated the realizations of "r" as a fricative by a 25 year-old university student from Minas Gerais, producing the pseudo word "raca". They state that posterior fricatives have a concentration of energy around 1,250Hz, which means the variant produced by the speaker is either a velar or uvular fricative. By experience and because speakers from Minas Gerais use this variant, they conclude that it is probably a velar fricative.

Figure 4 shows the production of the word *rir* (“to laugh”) by a female participant in the present study. The rhotic is realized as a voiced velar fricative, and, as stated above, because of the coarticulation, its F2 and F3 values are around the same as the vowel´s F2 and F3 values.

Figure 4 - *The word "rir" (to laugh), produced as [ɣih], by a 26 year-old female participant in the intermediate group.*

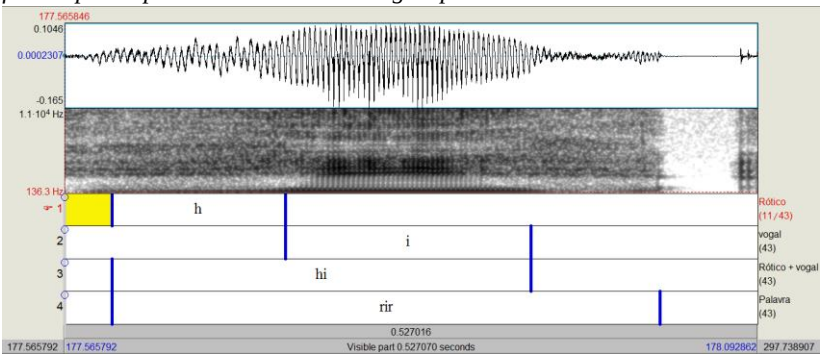
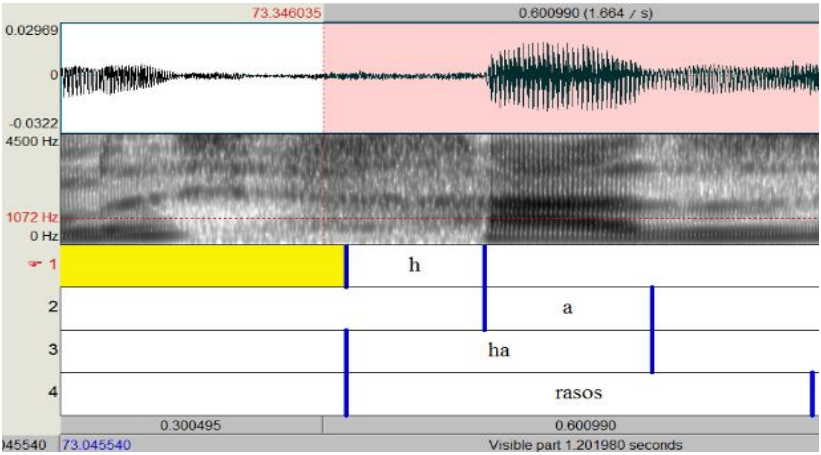


Figure 5 below shows the production of a voiceless glottal fricative produced by a female participant in the present study in Brazilian Portuguese in the word *rasos* ("shallow").

Figure 5 - *The word "rasos" (shallow), produced as [hazʊz], by an 18 year-old female participant in the beginners group.*



As for the "caipira r", the authors claim that this variant may be produced in different ways, especially in the state of São Paulo. Using data provided by Leite (2010), the authors investigate its productions in the words *torto* ('askew"), *Qatar* ("Qatar") and in the pseudo word "terto" by a female speaker. They conclude there is an approximation of F2 and F3, and a group movement of F2 and F3 towards a specific spectral region, around 1,950Hz. That indicates that the production is

more similar to that of a tap than of a velar consonant. Therefore, the articulation of the rhotic involves not only the approximation of the body of the tongue to the velar region, but also to the alveolar one, possibly using the tip or the blade of the tongue.

This section has defined the term "rhotic" and shown the distribution of the rhotic sounds in English and in Brazilian Portuguese. It has also presented an acoustic description of the retroflex and the fricative variants in English and of the "caipira r", the fricative and the tap in Brazilian Portuguese.

2.5 PREVIOUS STUDIES ON RHOTICS

In the following paragraphs, some studies on the rhotic sounds will be presented, both in English as an L2 and in Brazilian Portuguese.

2.5.1 Previous studies on rhotics in English

The studies to be mentioned in this section all deal with issues that concern the present study: the production of "r" by Brazilian speakers and L1 transfer.

A study carried out by Deus (2009) aimed at investigating whether there would be transfer of the Brazilian Portuguese 'r' to the production of English word-initial 'r', and whether the transfer rate would be higher for cognates. Participants were Brazilian English language university students from levels A2, B1 and B2[7], according to ALTE[8] Framework, and they all performed a reading task. The researcher found that there was little transfer (49 productions out of a total of 1800 tokens – 2.72%) but stated that the results may be attributed to the facility of the task. As for cognates, the author found that 50% of the words presented some kind of transfer in their production, against 20% of the non-cognate words.

[7] A2, B1 and B2 correspond, respectively, to levels basic user – waystage, independent user – threshold, and independent user – vantage.

[8] ALTE (The Association of Language Testers in Europe) The association exists to "promote multilingualism across Europe – and beyond – by supporting institutions which produce examinations and certification for language learners. Through our work we raise awareness of the benefits of a multilingual society, provide a forum in which related issues can be discussed, and set quality standards for language assessment." Source: http://www.alte.org/ - April, 2015.

Another study conducted by Osborne (2010) investigated the production of "r" by three Brazilian students of English, from ages 36 to 45, all living in New York at the time of the study – their stay in the USA varied from 45 days to 6 years. Two of them were from Minas Gerais and one was from Bahia. They all said to have had little or no formal instruction in English in their country. Data were collected by means of recordings in which the participants were asked to speak freely about any subject they wished. Data were then transcribed by the researcher and reviewed by a native speaker of English, who was also a more experienced researcher. Only the parts of the recordings containing the rhotics that both researchers agreed on were used in the study. Among the analyzed words, the participants produced the "r" in onset consonant clusters (e.g.[ˈsɛntɾaw]) mostly as a flap (71.69%). The researcher concludes that L1 transfer may have been the cause of those productions since in BP, "r" in two-member onsets is produced as a flap (or tap)[9].

Schadech (2013) conducted a study to investigate how intelligibility and comprehensibility might be affected by non-target production of rhotics by Brazilian speakers of English. The study revealed that only a few Brazilian learners of English transferred the L1 rhotic sounds to English, and such transfer happened mainly in word-initial position, where the English retroflex was replaced by a fricative. Factors like the frequency with which a word appears in a language might also have some influence on how it is pronounced by non-natives. It is easier for humans to learn and process high frequency words (Ellis, 2012). Ellis (2011, p.4) affirms 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." In Schadech's study, the author attributes the correct production of the word "right" by all participants to its high frequency in the English language.

The aforementioned studies show that L1 transfer may be the cause of non-target productions in the L2. Mostly, when L1 transfer happened in word-initial position, the rhotic was produced as a fricative,

[9] Authors disagree on the use of the terms "flap" and "tap", but most of them consider both different names for the same segment. For the present study, Reetz and Jongman's (2009) definition will be used, which says that the flap (or tap) consists of a single tap of the tip of the tongue against the alveolar ridge. Therefore, they do not make a distinction between the terms, using both interchangeably.

while in syllable-initial clusters, it surfaced as a flap. Moreover, it is important that production tests be as naturalistic as possible so as to avoid the task being too easy, which could influence results. Finally, the frequency of the word in the L2 might also influence the results of production tests.

2.5.2 Previous studies on rhotics in Portuguese

The following studies both deal with variables that are going to be addressed in the present research: F3 values of the rhotic preceded by different vowels and the pronunciation of the "r" sound in Portuguese by speakers from Florianópolis, SC, the city in which some of the participants in this study were born.

Ferraz (2005) conducted a study with speakers from the city of Pato Branco, Paraná, in Southern Brazil to investigate the production of "r" in medial and final coda. Speakers in that city produce the variant "retroflex approximant", which, as already mentioned, is so common in most varieties of English, and therefore may allow for a comparison with the English data. The study found no significant difference of F1, F2 and F3 values between the variant in medial and final position. However, it found values that point to a possible influence of the adjacent vowel on the retroflex approximant.

The rhotic's F1 values did not present a significant difference when comparing the segment adjacent to front and back vowels. Nonetheless, F2 and F3 values were significantly higher before front than before back vowels. F2 average value before front vowels was 1,651.96Hz and before back vowels it was 1,291.31Hz. F3 average value before front vowels was 2,241.07Hz, while before back vowels it was 1,923.09Hz. Although that study and the present one investigate the rhotic in different positions, coda and onset, respectively, because the segments are adjacent, we could predict that F3 values will be higher also for the rhotic before front vowels than before back vowels.

Another study on rhotics was conducted by Campos, Brod and Seara (2013), with 3 informants from the cities of Maringá (in the state of Paraná) and Florianópolis (in the state of Santa Catarina). The informants were three women of 18, 46 and 66 years of age. One of them had lived in Maringá since she was 1 year old, the other lived for 23 years in Maringá and was living in Florianópolis at the time of data collection, and the third had lived all her life in Florianópolis. The study collected data through the reading of a text, of carrier sentences and of a list of words, having a total of 90 tokens. Results indicate that in

Florianópolis, both in onset and in coda, the variants velar and glottal fricatives are the predominant productions of "r". On the other hand, for Maringá, the main production in onset is the velar fricative and in coda, it is the retroflex.

This section has shown some studies on L1 transfer and on the production of rhotics in Brazilian Portuguese. The three first studies were conducted with Brazilian learners of English, and all of them concluded that there was at least some transfer from BP in the production of the rhotic in English. The fourth study showed that the adjacent vowel in BP affects the rhotic's formant values. The fifth study reports on the production of the rhotic by speakers from Florianópolis in onset: a fricative variant. Next, I present some studies on the role of proficiency in L2 pronunciation.

2.6 THE ROLE OF PROFICIENCY IN L2 PRONUNCIATION

Another variable that plays an important role in the pronunciation of L2 sounds is the speakers' proficiency level. The longer learners are exposed to the L2 and as they develop and acquire new features of this second language, the more their phonological system improves. Therefore, it is expected that, the higher the learners' proficiency, the more target-like productions they will have. Next, I present studies that deal with proficiency in L2 pronunciation.

A study carried out by Silveira (2012) aimed at investigating the relationship between L1 transfer to English word-final consonants and individual differences. One of the learner profile characteristics to be investigated was proficiency level. The study was carried out with 31 Brazilian speakers who had been living in the USA at the time of data collection, and two American speakers who participated as controls. The age of the Brazilian participants ranged from 19 to 60 years old. Data were obtained by means of a sentence-reading task, a questionnaire, and an oral picture-description task to determine L2 proficiency level. The study found that target-like productions of word-final consonants were strongly related to proficiency level: "It is the development of L2 proficiency that ultimately seems to lead to target-like production of English word-final consonants" (Silveira, 2012, p. 30).

A similar finding is reported by Zimmer (2004), who investigated the production of English word-final codas by 156 Brazilians from four different proficiency levels. The participants were recorded reading a list of English words and non-words. The researcher found that a number of phonological processes were more frequent among participants who

were less proficient: vocalization of final nasals (e.g., 'room' [ɹuˇ]); simplification of consonant clusters (e.g., 'spy' [ispaɪ]); vocalization of final /l/ (e.g., 'feel' [fiw]), consonant substitution (e.g., 'red' [hɛd]), and vowel insertion after codas (e.g., 'pig' [pɪgi]).

As the aforementioned studies concluded, although this is not a rule, the more proficient the learners, the more target-productions they are likely to have.

2.7 STUDIES ON THE INFLUENCE OF AGE OF ONSET ON L2 PRONUNCIATION

It is common knowledge among SLA theories that the earlier a learner starts having contact with the L2, the easier it is for them to acquire the phonological system of this L2 (Ellis, 2008; Flege, 1999). Flege (1999) also claims that it is not that learners lose their capacity to learn the new phonological system, but rather that the L1 is usually so deep-rooted that it is hard to differentiate especially sounds that are very similar in the L2. In her paper, Moyer (2007) cites several studies (Bohn & Flege, 1992; Flege, 1991; Flege & Hillenbrand, 1987; Flege & Mackay, 2004; Moyer, 1999, 2004, 2007a; Pallier, Bosh & Sebastian-Galles, 1997; etc, cited in Moyer, 2007) that indicate that L2 phonology can be especially difficult to acquire after puberty. Below there are some studies on the age factor in L2 pronunciation.

A study by Bongaerts et al. (1997) aimed at defining whether late Dutch learners of English could achieve native-like pronunciation. The research counted on three groups: one of 10 native speakers of British English (control group); another of 11 highly successful English learners native speakers of Dutch (all with an AO around 18); and 20 native speakers of Dutch with different levels of English. Results show that some of the highly successful learners obtained scores similar to the native speakers, which would be an indication that it is possible for late learners to achieve native-like pronunciation. However, the authors note that the highly successful learners did receive intensive training in the production and perception of speech sounds of British English.

Another study conducted by Flege and Yeni-Komshian (1999) with 240 native speakers of Korean who had arrived in the USA from 1 to 23 years of age and had an average length of residence of 15 years tested, among other things, their pronunciation. Native English speakers rated the participants' performance on a series of tests. And a control group of native English speakers was also used. The authors found that, as AO increased, participants' foreign accent increased. However, even

those participants who had arrived in the USA as children had much lower rates than the native English controls in the pronunciation tests.

Lima (2015) investigated whether the AO might have any kind of influence on the acquisition of vowels by Brazilian learners who had started their English courses at different ages in Brazil. The learners were divided into 3 different groups: G1 – AO up to 12 years-old; G2 – between 12 and 14 years-old; and G3 - after 16 years-old. The study also counted on a control group composed of 10 native speakers of English, 5 women and 5 men (aged between 18-74). The vowel pairs investigated were /i/ and /ɪ/, /ɛ/ and /æ/, /u/ and /ʊ/. The hypothesis that the higher the AO, the greater the difficulty in acquiring the target vowels would be was confirmed. However, age was not a determining factor, since even the group with the lowest AO had results that differed a lot from the control group.

The previous sections have summarized some studies conducted on rhotics in English as L2, Portuguese as L1, on the role of proficiency in L2 pronunciation, and on the role of age on L2 pronunciation. As it could be seen, higher proficiency levels tend to lead to improvement in learners' pronunciation, although that is not a rule. Furthermore, a higher AO usually indicates more difficulty in pronouncing sounds in the L2. Based on the information presented so far, I now present the research questions and hypotheses that guide the present study.

Research Questions

(1) Is the production of English rhotic sounds between beginner and intermediate students different?
H1 - There will be a higher number of non-target productions by beginner students, due to L1 transfer, which may happen especially in the first stages of the learning process (Osborne, 2008, Silveira, 2012, Zimmer, 2004).

(2) How does the following vowel affect the production of the English rhotic sound by Brazilians?
H2 – F3 values of the tokens produced as retroflex approximants preceding front vowels will be higher than for the variants that precede back vowels (Ferraz, 2005). As stated in the Review of Literature, the retroflex's typical characteristic is a low F3 value, which represents the movement of the tongue: the greater the movement, the lower the F3. Therefore, it was decided to investigate only the values of the third formant in the present research.

(3) How is age of learning related to the production of English rhotics?
H3 – Participants who began studying English at an earlier age will produce the rhotic sounds more accurately than the ones who have a higher AO. According to the SLM's H4 (Flege, 1995), due to neurological maturation, fewer sounds in the L2 will be produced accurately by learners as their AO increases. Granena and Long (2013) also found in their study with Chinese learners of Spanish that none of the 65 participants with an AO beyond 5 achieved native-like pronunciation. Long (1990) also claims that there is an agreement among researchers about the existence of a sensitive period for phonological acquisition that closes around age 12.

The next chapter is an account of the method used in order to conduct the present study.

CHAPTER THREE - METHOD

The chapter presents, respectively: a) a description of the pilot study; b) the instruments used for data collection and the procedures involved in that process; c) an overview of the profile of participants; d) the criteria adopted for creating the corpus of the production test, and for data segmentation and analysis.

3.1 PILOT STUDY

Before the present research was conducted, a pilot study was carried out in order to test instruments and try to minimize errors posteriorly. Below, there is a description of how the pilot study was conducted, the results it yielded, and a discussion of how the pilot study informed the design of the MA research. The study was submitted to the UFSC Board of Ethics in Research (CEPH) and approved under the protocol number 1.466.601/2016 (See appendix G).

3.1.1 Participants

The pilot study counted on 4 participants. They were two beginners (one female and one male) and two intermediate speakers (one female and one male). Their ages ranged from 25 to 29 years old, and they all had been born and lived their whole lives in Florianópolis, SC. However, all of them had already lived in different cities in Brazil for a period that ranged from 6 months to 6 years. None of them had lived abroad. Their age of onset varied from 6 to 20 years old. The average time they had spent studying English as adults was 2.1 years. All of them reported practicing English for an average of 1.7 hours a week outside the classroom. Moreover, they reported practicing English by watching movies and TV series, listening to music, talking to friends and one participant said she used a telephone application to study the language. All of the participants said they liked the language and reported studying it as a hobby, to learn a second language or because they needed it for their jobs and/or studies.

3.1.2 Research Questions

The pilot study had two research questions and two hypotheses, as follows:

1. Is there a difference in the production of rhotic sounds in English between beginner and intermediate learners?
H1 - There will be a higher number of non-target pronunciations for beginner students, due to L1 transfer, which may happen especially in the first stages of the learning process (Osborne, 2008, Silveira, 2012, Zimmer, 2004).

2. Does the following vowel affect the production of the rhotic by Brazilian learners?
H2 – F3 values of the tokens produced as "retroflex approximants" preceding front vowels will be higher than for the variants that precede back vowels (Ferraz, 2005).

3.1.3 Instruments

The instruments used in the pilot study were the same as those used for the actual study carried out posteriorly: a consent form, a questionnaire to collect relevant data on each participants' profile, a proficiency test (Oxford Placement Test, Allan, 2004), and two production tests (one in Portuguese and another one in English).

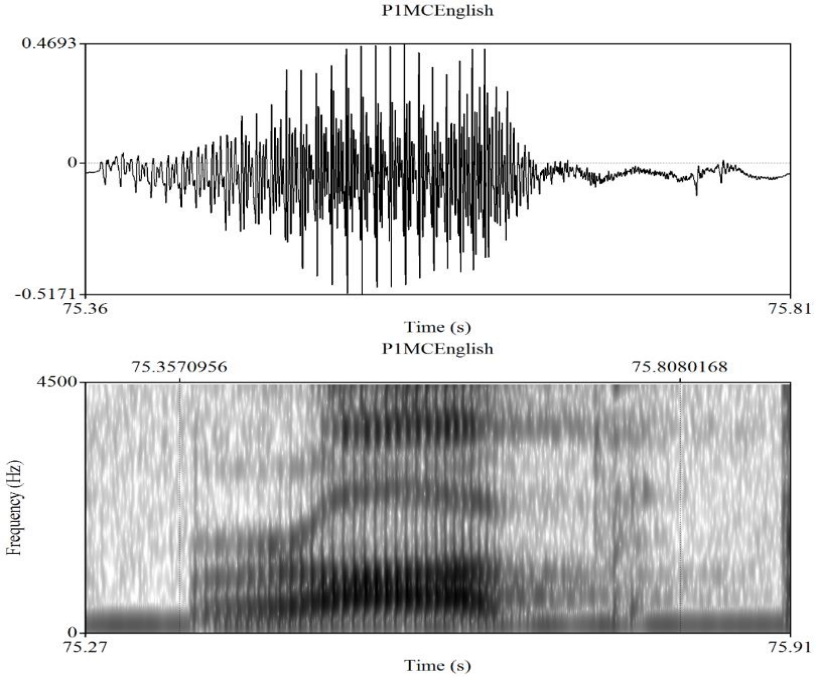
The production test in BP contained the following words with the rhotic in onset position: *rasos* ("shallow"), *rede* ("hammock"), *riso* ("laughter"), *roxo* ("purple"), *rude* ("rude"), *rir* ("to laugh"), and *régua* ("ruler"). Appendix C shows the complete test, which was maintained for the posterior study. The target words in the English production test in the pilot study were: "rap", "read", "rich", "Rob", "run" and "rib". The word "read" was used in two different sentences. Appendix C shows the complete production test used in the pilot study.

3.1.4 Data Analysis

Analyzing data from the production test in BP, it was possible to conclude that the acoustic characteristics of the fricative described by Ladefoged (2011) and Machač and Skarnitzl (2009) were present in the productions of all the participants. They all used the fricative variant for the orthographic "r" in onset position in their mother tongue.

Considering the characteristics shown in the literature on each type of rhotic, it could be observed that the Brazilian speakers produced the rhotic as both retroflex approximants and fricative variants in English. Below, we can see in which situations and to which participant each production refers to.

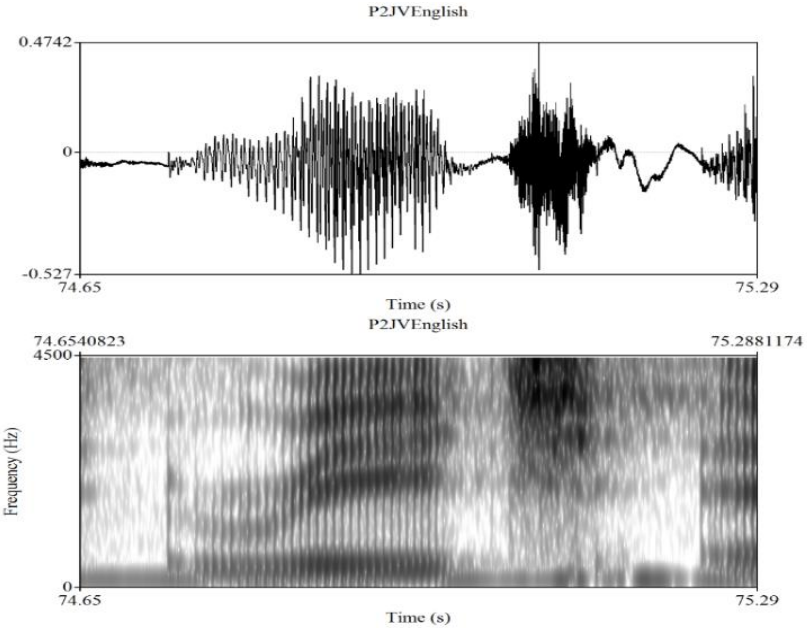
Figure 6 - *The word "Rob", produced by a male intermediate learner in the pilot study.*



In the spectrogram presented in Figure 6, it is possible to see the production of a retroflex approximant by participant 1 in the pilot study. The participant was an intermediate male learner, and F1, F2 and F3 values are, respectively: *361Hz, 933Hz and 1,537Hz*.

In Figure 7, we can see another production of the retroflex approximant, similar to that of the English language, now by a beginner learner. In this production of the retroflex, F1, F2, and F3 values are very low: 328Hz, 1,138Hz e 1,785Hz, respectively, and F2 and F3 are close together. It is also possible to visualize the transition of the retroflex to the next vowel [i], where there is a clear opening between F1 and F2, which indicates the transition to the high vowel [i].

Figure 7 - *The word "rich", produced by a male beginner learner in the pilot study.*



All participants produced at least 3 non-target variants (glottal fricative) of the rhotic in English, which was the same used in their BP productions. The number of non-target variants was exactly the same between beginner and intermediate participants. Table 1 shows the productions of the fricative in place of the retroflex and the target productions of the 4 participants.

Table 1 - *Production of fricatives instead of the retroflex and target productions of the 4 participants in the pilot study.*

Participant	**[h] in place of** [ɹ]	**Words with the fricative instead of the retroflex**	**Target productions**
P1 – Intermediate	3 – 14,28%	Rap – 3	18 – 85,71%
P2 – Beginner	3 – 14,28%	Rap – 3	18 – 85,71%
P3 – Intermediate	4 – 19,04%	Rap – 2 Run – 1 Rib – 1	17 – 80,95%
P4 - Beginner	4 – 19,04%	Rap – 3 Rob - 1	17 – 80,95%

When answering the first research question, the conclusion was that, for the pilot study, there was no difference between the production of the rhotic in onset position between beginner and intermediate learners. Thus, H1 was not confirmed, since it predicted a higher number of target productions by intermediate learners. Moreover, we could hypothesize that the productions of the fricative instead of the retroflex approximant in the word "rap" may have been due to the fact that this word is a linguistic borrowing from the English language. We also use it in BP to designate the musical genre. However, in BP the initial "r" is pronounced as a glottal or velar fricative in the participant's dialect and this might have led participants to produce it the same way, even though the sentence was in English. The same thing might have occurred with the proper name "Rob" since it is also used in BP, although it is not such a common name.

In order to answer the second research question, F3 values of the retroflex before different vowels were observed, as well as the coefficient of variation, which is calculated by dividing the standard deviation by the F3 medium, and then multiplying it by a hundred.

In section 3.5 explanation on how data was segmented and submitted to acoustic analysis is provided.

Table 2 - *Data distribution, average of the retroflex's F3 frequencies and of the coefficient of variation before different types of vowels.*

Retroflex before:	**F3 (data interval)**	**F3 Medium (in Hz) and Coefficient of Variation (%)**
[æ]	1631-1664 Hz	1647 (1.46%)
[ʌ]	1483-1629 Hz	1556 (4.55%)
[i] or [ɪ]	1728-2460 Hz	2094 (5.64%)

F3 value mediums of the retroflex presented on Table 2 correspond to data extracted in the medial region of the segment, which is the most stable one. According to Seara (2000), data with a coefficient of variation below 25% represent data that are just consistent. Since the data presented in the Table 2 present a coefficient of variation below 25% - most of them below 10% - it can be concluded that the data are homogeneous and therefore do not represent a great variation.

Looking at results, it can be concluded that the following vowel seems to affect the rhotic in onset position, as predicted in Silva (1996) and in Ferraz (2005), although no statistical tests were run for the pilot study to support such conclusion. If we look at formant values shown in

Table 2, it is possible to see the difference of the formants of the rhotic that seem to be affected by the vowel that follows it. The retroflex's F3 values were the highest before the front vowels [i] and [ɪ] (2,094 Hz), but not for [æ] (1,647 Hz), which was very low and similar to the rhotic's F3 value before the back vowel [ɑ] (1,556 Hz). In the actual study, statistical tests were run in order to support the significance of all conclusions drawn.

3.1.5 Conclusion

As it has been presented above, there were no differences in the production of rhotics between beginner and intermediate participants. Both groups produced the same number of non-target variants for the rhotic in English - [h] in place of [ɹ]. That does not confirm hypothesis 1 of the pilot study, which predicted that beginner participants would have more non-target productions. Moreover, the production of a fricative variant in the word "rap" – only one participant produced this word with a retroflex in one of the three repetitions – might have been due to the fact that the word is used in BP as a linguistic borrowing from English and, therefore, it could be said that there was L1 transfer. However, most productions of all participants (above 80%) used the retroflex approximant. To reach such conclusion, an analysis of F3 values of the rhotic produced by each participant was carried out to aid the auditory analysis of the tokens.

As for the second research question, it was concluded that there seems to be a certain influence of the following vowel on the retroflex, as it had been predicted in H2. It is possible to say that before the high vowels [i] and [ɪ], the rhotic´s F3 is the highest of all F3 values before the other investigated vowels. This data is consistent with formant values for the front vowels [i] and [ɪ]. According to Rauber (2006), the medium of F3 values for [i] and [ɪ] when produced by female speakers are 3,322Hz and 2,989Hz, respectively, and 2,934Hz and 2,648Hz when produced by male speakers. Among the vowels investigated for this research question, [i] and [ɪ] have the highest F3 values.

Although the pilot study allowed the researcher to draw some conclusions, it is important to emphasize that it counted on just 4 participants and 84 productions in English, which does not represent a very relevant amount of data. Moreover, the profile of the participants was very similar. And, finally, no statistical tests were run to prove whether the differences presented in the conclusions are really

meaningful. Therefore, for the actual study, the following changes were made:

- A question was added to the questionnaire in order to gather information about where and for how long the participant had studied English in the past;
- a distractor – small passage - was added to the production test in English in order to set the participant in the English mode since, up to that point, they had been reading only in Portuguese;
- some tokens of the production test in English were changed. The word "read", which appeared in two different sentences, was changed in one of them to "rats" so that there would be different contexts to be analyzed. The words "rap" and "Rob", which are cognates were changed into "red" and "rods", respectively, in order to avoid leading participants to L1 transfer, as mentioned in the study conducted by Deus (2009) in the Review of Literature. Furthermore, the word "polite" was changed to "smart" because participants in the pilot study had had difficulty pronouncing it.
- sample size was changed, having all the repetitions of the tested words analyzed – 21 tokens for each participant.

3.2 PARTICIPANTS, INSTRUMENTS AND DATA COLLECTION PROCEDURES

This section will report on the participants' profile and data analysis. It will also present the instruments used in order to collect data for the present study as well as the procedures taken to collect such data and to create the corpus of the study. The instruments used were: a consent form; a questionnaire; a proficiency test; and two production tests, which are described in detail below.

3.2.1 Participants

The participants in this study were 10 beginner and 10 intermediate Brazilian learners of English, both female and male. The beginner group had nine women and one man, and the intermediate group had six women and four men. All of them were over 18 years old by the time of data collection. Some of them were regularly enrolled at the Extracurricular Program at UFSC (7 beginner learners and 5

intermediate learners), and others were students who had regular private English classes (3 beginners and 5 intermediate learners). All of them volunteered to participate in the research. Their age of onset ranged from 9 years-old to 47 years-old. The age of onset was considered to be when they started taking any kind of course (private or at language schools) other than courses at school. [10] They had been studying English for at least one month at the time of data collection and most participants also dedicated some time to studying English outside the classroom, through films and TV series, music, talking to friends and colleagues, reading and writing scientific articles, and using telephone applications. Most participants reported that they liked English and why they studied it - as a hobby, to learn a second language, because they need it for their studies or work, and also to travel.

Table 3 shows participants' age, education level, place of birth and place where they had lived the longest at the time of data collection.

[10] This decision was made based on the fact that in Brazilian schools, both private and public, foreign languages are taught with an emphasis on reading skills and grammar, and generally little or no attention is given to the oral component.

Table 3 - *Participants' profile.*

Participant	Level	Age	Education	Place of birth	Place they lived the longest
P1	Beginner	18	Undergraduate student	Florianópolis - SC	Florianópolis - SC
P2	Beginner	28	Master´s degree	Ijuí - RS	Ijuí - RS
P3	Beginner	21	Undergraduate student	Curitibanos -SC	Curitibanos -SC
P4	Beginner	19	Did not say	Florianópolis - SC	Florianópolis - SC
P5	Beginner	19	Undergraduate student	Florianópolis - SC	Florianópolis - SC
P6	Beginner	45	Master´s degree	Recife - PE	Recife - PE
P7	Beginner	30	Master´s degree	Florianópolis - SC	Florianópolis - SC
P8	Beginner	66	Did not say	Arroio dos Ratos - RS	Porto Alegre - RS
P9	Beginner	31	PhD student	Brusque - SC	Florianópolis - SC
P10	Beginner	31	Master´s degree	Florianópolis - SC	Florianópolis - SC
P1	Interm.	21	Undergraduate student	Palhoça - SC	Palhoça - SC
P2	Interm.	26	Undergraduate student	São José - SC	Santo Amaro da Imperatriz - SC
P3	Interm.	29	University Degree	Florianópolis - SC	São José - SC
P4	Interm.	42	University Degree	Florianópolis - SC	Florianópolis - SC
P5	Interm.	24	Undergraduate student	Florianópolis - SC	Florianópolis - SC
P6	Interm.	23	Undergraduate student	Florianópolis - SC	Florianópolis - SC
P7	Interm.	32	Undergraduate student	Belo Horizonte - MG	Rosário do Sul - RS
P8	Interm.	31	University Degree	São Paulo - SP	São Paulo - SP
P9	Interm.	20	Undergraduate student	Venâncio Aires – RS	Florianópolis - SC
P10	Interm.	35	Master´s degree	Joaçaba - SC	Xanxerê - SC

Table 4 presents the mean age, age of onset and language experience of participants.

Table 4 - *Participants' mean age, age of onset and time studying English.*

Mean Age	Mean Age of Onset	Mean time studying English
29.5 years-old	17.5 years-old	3.6 years

3.2.2 Consent form

The first instrument used by the researcher in this study was a consent form (appendix A). It is written in Portuguese and it was explained to the participants that the study was conducted through the Post-Graduation Program in English at UFSC. It also stated that the objective of the study could not be revealed at that moment in order not to influence data collection. However, participants were informed that their participation in it would possibly help in the making and improvement of educational English books for Brazilian learners in the future. Moreover, the participants were informed that, in addition to signing the consent form, they would have to take a proficiency test and participate in two sentence-reading tasks, one in Portuguese and another one in English. Furthermore, they were informed that their names would be kept in confidentiality and the data obtained would only be used in order to compose the corpus of the present study. Finally, the participants were told that if, at any moment, they felt uncomfortable or tired, they could end their participation and/or request their data not to be used.

3.2.3 Questionnaire

The second instrument used for data collection was a questionnaire (appendix B) that aimed at understanding the participants' experience in learning the English language and also obtaining some personal information that would be relevant to the study. It requested that participants filled in their names, age, places where they had lived before, age of onset, whether they had lived in an English speaking country and for how long, how they had learned English (at English schools, private classes, at school, on their own, etc) and for how long. Furthermore, they were supposed to inform how much time a week they dedicated to studying the language, whether they liked English or not, how they practiced their knowledge of English when not in class or studying, and what their reasons for studying English were.

After the pilot study was carried out and based on participants' feedback, it was added to the question "How old were you when you started learning English?" in the questionnaire the information of whether that had happened at school, at an English school, etc, and for how long.

3.2.4 Proficiency Test

The third instrument used for data collection was the proficiency test. It was used a pen and paper version of the Oxford Placement Test (Allan, 2004). The test consists of 60 multiple-choice questions to assess students' reading, vocabulary and grammar skills. Since data for the present study is based on a reading task, the test is considered appropriate. The test scores classify students according to the CEFR (Common European Framework) as follows: A1 and A2 – basic users, B1 and B2 – independent users, C1 and C2 – proficient users. For the present study, the categories were classified as beginner (A1 and A2 levels), intermediate (B1 and B2 levels) and advanced (C1 and C2 levels).

A convenient time, date and place for the participant to take the test was set. The researcher then gave instructions in Portuguese on how to proceed with the test until it had been completed. Finally, each participant's answers were checked with the answer key provided and participants were ranked according to their level of proficiency. Only participants who were beginners or intermediate students continued to take part in the study.

3.2.5 Production Test

The fourth instrument was a sentence-reading task that was used to collect production data. The production test (appendix D) was divided into two parts: the first, in Portuguese, aimed at establishing which rhotic variant was used by each participant in their mother tongue; and another one in English to examine how the participants pronounced the English rhotic.

After the pilot test, it was decided to include a distractor before the English production test. The distractor is a short passage in English. The reason to include it is to set the participant in the English mode, since up to that point, they had only read sentences in Portuguese and then suddenly they were required to read in the L2. Therefore, it could be said the distractor was a familiarization test, which helped each

participant become more comfortable with reading in English before actually starting the production test in the L2. The distractor was placed before the English production test, but in the same file, so that it would be read in the same recording. The reason for that is simply to avoid having to stop the recording and resume it later. When analyzing data, the passage was excluded.

The Portuguese test contained seven sentences, which were repeated three times in random order by each participant. The words containing the rhotic sounds in Portuguese were: *rasos* – ('shallow'), *rede* ('hammock'), *riso* ('laughter'), *roxo* ('purple'), *rude* ('rude'), *rir* ('to laugh'), and *régua* ('ruler'). All the words were inserted in sentences and always appeared after a pause, which made it easier to visualize the rhotic sounds in the spectrogram of the acoustic analysis that was carried out posteriorly.

In the pilot study, the production test in English contained seven sentences, with the following target words beginning with the rhotic sound: "rap", "read", "rich", "Rob", "run", and "rib". After the pilot study, some of the words in the English production test were reconsidered and changed. The word "read", appeared in two different sentences and therefore a different word was chosen instead in order to have more vocalic environments to analyze. One of them was changed to "rats".

Furthermore, the word "rap" was changed. The reason for that is that even some of the participants that had a target pronunciation of the rhotic sound for all the other words pronounced this one in a non-target manner. A possible explanation is that the word "rap" is a borrowing from the English language, and therefore, its pronunciation has been adapted to the Portuguese language, using [h] rather than [ɹ], and thus sounding like [hæp]. Consequently, it was difficult for participants to produce the target-like variant. The word was changed to "red".

As a way to prevent something similar from happening with the word "Rob", a proper noun that is also used in Portuguese and may sound like [hʌb], it was changed to "rods". Another word ("polite") that presented difficulty to some of the participants did not contain a rhotic sound, but influenced in the reading of the sentence as a whole. Two of the participants in the pilot test had problems pronouncing it and had to repeat it. Therefore, it was changed to "smart", which is a more common word in spoken language, according to the Corpus of Contemporary

American English (COCA)[11]. Thus, in its final version, the English production test contained the following words: “red”, “read”, “rich”, “rods”, “run”, “rats” and “rib”.

The same procedures used for the test in Portuguese were used for the test in English: both tests were read by participants and recorded by the researcher.

As for data collection, it was done individually by the researcher, either on a laptop computer or on the language laboratory desktop computer. The production test sentences were displayed on the screen, and the participants were able select the next sentence when they had finished reading the previous one. A Phillips - Shg 7210 Stereo Headset was used by participants in the reading of the sentences in the production test.

First, the researcher ensured that the participant was comfortable and had understood the instructions in order to proceed with the reading tasks. Then, the participant read the sentences in the order that they appeared on the computer screen. The researcher was supervising the recording of the sentences and interfered or stopped the process in order to help or correct any procedure that might not have been carried out properly. The first production test to be read was the one in Portuguese and, the second was the one in English. After each test had been recorded, the researcher played it and ensured that the recording was suitable for posterior analysis. In case there had been any problems, the participant was asked to record it again.

When recording participants 2 and 5 in the beginner´s group and participant 3 in the intermediate group, there were technical problems with the laboratory equipment. The participants in the beginner group were asked to record the production tests at the phonetics laboratory one more time. As for the participant in the intermediate group, the problem was observed after she had already left and, therefore, the production test was recorded again at a different place, with a laptop computer and a headset.

[11] The word “polite” appears 4813 times in the corpus while the word “smart” appears 21594. Retrieved from http://corpus.byu.edu/coca/ on April 20, 2015.

3.3 CRITERIA ADOPTED TO CREATE THE CORPUS OF THE STUDY

All the words in the production tests containing the rhotic sounds to be analyzed acoustically were carefully chosen according to some criteria. First of all, the target words in the English test are all monosyllables, and in the Portuguese test, they have a maximum of two syllables (only one is a monosyllable). The reason for that is because one-syllable words are not very common in Portuguese. Second, the vowels that follow the rhotic are varied, so all of them can be analyzed later. The vowels following the rhotics in English are /ɛ/, /i/, /ɪ/, /ɑ/, /ʌ/, and /æ/, and in Portuguese they are /a/, /ɛ/, /e/, /i/, /o/ and /u/. According to Silva (1996), there might be an influence of the following vowel on rhotics in onset. Third, there is only one cognate (the word "rats") and no linguistic borrowings among the target words in English in order to avoid increasing the chance of L1 transfer taking place.

Besides the aforementioned criteria, the words containing the rhotics in both tests all appear in the middle of real sentences and after a pause. Those decisions were taken, once again, as attempts to make it easier to carry out the acoustic analysis of the rhotics subsequently. Because rhotics have some vowel-like features (Ladefoged & Maddieson, 1996), it might be challenging to define the limits of segments in the transition from the rhotic to a vowel or from a vowel to the rhotic. That is why the target words were placed after a pause. The decision to keep the target words in the middle of the sentence was taken because words at the end of sentences might be produced with less energy, and therefore, the signal would not be appropriate for acoustic analysis.

3.4 DATA ANALYSIS

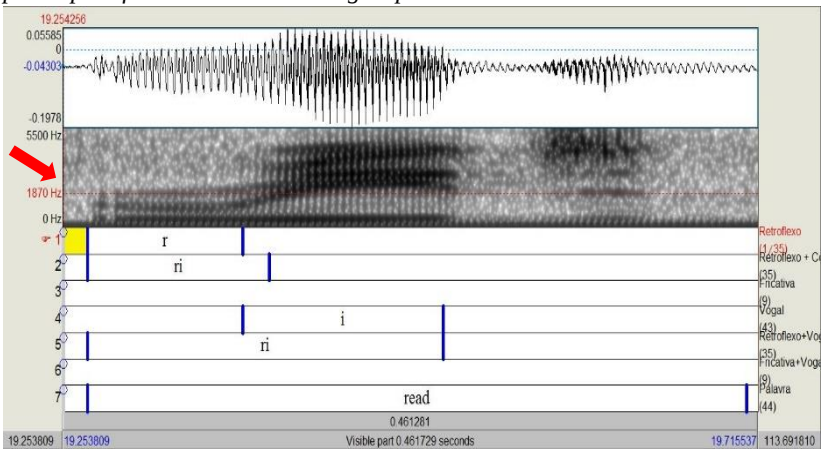
As mentioned in the participants section, this study counted on both female and male participants. Therefore, due to the physiological differences among genders, which can lead to different acoustic features, data analysis was done separately for both men and women.

After collecting the data from all participants, the next step was to segment the target words on PRAAT (Boersma & Weenink, 2014). Since the focus were the rhotic variants in onset position, only the words containing them were segmented. As shown in figure 8, one tier was created for the retroflex, one for the retroflex and the co-articulation with the vowel, another one for the fricative, a fourth one for the

following vowel, a fifth one for the coarticulation and the vowel, a sixth one for the syllable with the retroflex (retroflex + vowel), a seventh one for the syllable with the fricative (fricative + vowel) and one last tier for the entire word.

Figure 8 shows the production of the word “read” produced by a 26 year-old female Brazilian learner of English. It displays the segmentation of the rhotic itself, and on the second tier, the rhotic with the following coarticulation. It can be seen how difficult it is to see the transition from one segment to another. It also shows the rhotic’s F3 value (1,870Hz), shown by the red dotted line, indicated by the red arrow.

Figure 8 - *The word “read”, produced as [ɹid] by a 26 year-old female participant from the intermediate group.*



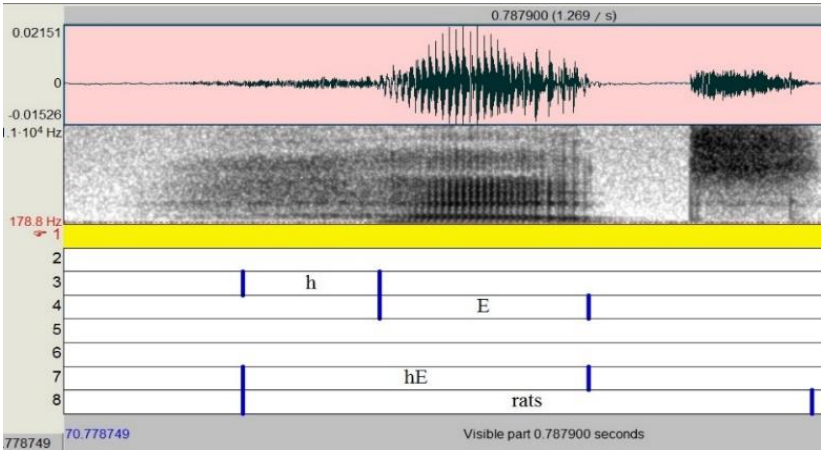
Because rhotic sounds have some “vowel like” features (Ladefoged & Maddieson,1996), it may be challenging to separate them from the following vowel in a spectrogram. When segmenting data, the criteria adopted by the researcher was that suggested by Machač and Skarnitzl (2009), which say the rhotic should be segmented according to the delimitation of the cycle, or where the low intensity part is located. Lawson, Stuart-Smith, Scobbie, Yaeger-Dror, and Maclagan (2011) also suggest that determining where the rhotic should be segmented depends on considering where the amplitude of the signal drops abruptly. So, the liquid sounds may be delimited where the amplitude is lowest. However, even following the authors’ criterion, determining where one segment ends and another one begins can prove to be a difficult task.

Since the segments (retroflex and vowels) have many similar characteristics, the co-articulation in the fifth tier was segmented with the vowel. On the second tier, the rhotic was segmented with the co-articulation. The reason for that was that when visualizing data extracted from the script, it was easier to visualize the differences between the rhotics when followed by different vowels.

As for the acoustic analysis of fricatives, Machač and Skarnitzl (2009) suggest that we should consider the structure of the vowel formants as the first criterion for data analysis, while striving to find the highest possible consistency and comparability. Moreover, the authors suggest that where it is difficult to identify the limit of the transition between segments, we should place it next to the nearest zero-crossing, from the midpoint. Therefore, those were the procedures taken to segment the words produced with a fricative variant.

Figure 9 shows the segmentation, waveform and spectrogram of the word "rats" produced with a voiceless glottal fricative, by an 18 year-old female Brazilian learner of English. It is very challenging to separate the segments only by looking at the spectrogram. The waveform and the auditory analysis aid segmentation in this case.

Figure 9 - *The word "rats", produced as [hætz] by an 18 year-old female participant from the beginners group.*



After having segmented data, a 3-point script was used to extract formant values and analyze each target-word. The used script was *"Gera Tabelas"*, (appendix E) developed by Fernando Pacheco from the *Laboratório de Circuitos e Processamento de Sinais (LINSE)* at

Universidade Federal de Santa Catarina. Using PRAAT, the script was run and it analyzed segments in 3 different points, extracting formant values. When extracting formant values, the middle point is chosen because it is the most stable one. For the present study, F3 values were extracted.

Finally, in order to run statistical tests, the software SPSS, version 17.0 was used. The first step before running the statistical tests was to determine whether data had normal distribution or not. Having confirmed that the distribution was not normal, non-parametric tests had to be used for each research question. For the first research question, both the Mann-Whitney test and the correlational test Spearman's rho were run. The first one was used in order to determine the significance of comparisons per group (beginners vs. intermediate), and the second one was used to check whether variables were related (proficiency level and non-target productions). For the second research question, the Wilcoxon test was used to compare the F3 values of rhotics produced before front and back vowels. And finally, for the third research question, Spearman's rho correlational test was also run to check for a relationship between age of learning onset and number of non-target productions. For all statistical analyses, the alpha value was set at .05. The SPSS output for all statistical tests are displayed in Appendix F.

This chapter has described the instruments that were used and the procedures that were taken for the collection of data for the present study. It has also presented the profile of the participants, and finally, it was shown how the corpus of the study was created, and the criteria adopted for data segmentation and analysis was described. Next, I present the reporting and discussion of the findings.

CHAPTER FOUR - RESULTS AND DISCUSSION

This chapter will present the results of the study drawn from data analysis and in accordance with the literature proposed in chapter 2. In order to answer the three research questions, they are revisited in each section, along with the hypotheses proposed. The chapter begins with the analysis of participants' productions of the rhotic in Portuguese and then it brings their productions for the English tokens, followed by the research questions and their discussion.

For research question 1, all participants' data were analyzed. When answering the question, the auditory analysis and the waveform inspection aided analysis, making it possible for all the data to be used, even the productions that had poor sound quality.

Since answering research question 2 required accurate values of the third formant of the retroflex variant, data pertaining to participant 9 in the beginners group and participants 3, 4, 7 and 9 in the intermediate group were excluded. Those participants' recordings were difficult to analyze acoustically due to their poor quality. When the script was run, the frequencies of segments did not match those shown in the spectrogram. Furthermore, for some tokens, it was not possible to visualize the formants clearly, possibly because of noise in the recordings.

4.1 BRAZILIAN PORTUGUESE RHOTIC VARIANTS

The production test in Portuguese was used to determine which rhotic variant each participant used in their mother tongue. The results showed that nineteen participants produce the rhotic in onset position as either a glottal fricative or a velar fricative, but mostly as a glottal fricative. The remaining participant realized the rhotic as a trill. Figures 10 and 11 show examples of productions of "r" with both velar and glottal fricatives.

Figure 10 shows a production in the Portuguese test by a female participant, who used the variant voiceless glottal fricative [h] for the orthographic "r". As stated in the review of literature, a simpler waveform is an indication of the variant.

Figure 10 - *The word "rasos" (shallow), produced as [hazʊz], by an 18 year-old female participant in the beginners group.*

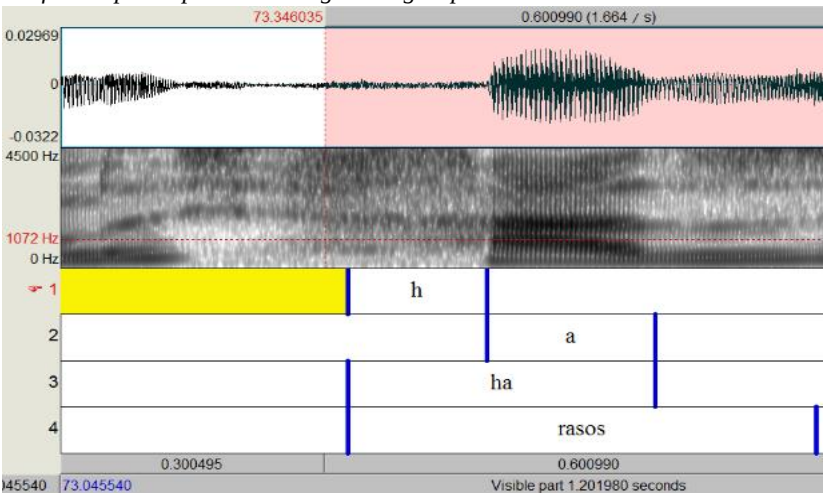
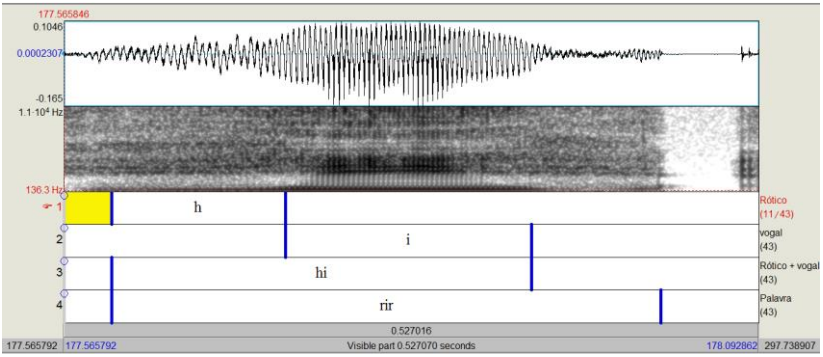


Figure 9 shows a production by a 26 year-old female participant in the intermediate group, who pronounced the orthographic "r" in onset as a voiced velar fricative [ɣ] in Portuguese. As stated in the review of literature, the rhotic´s F2 and F3 values are around the same values of the vowel´s F2 and F3.

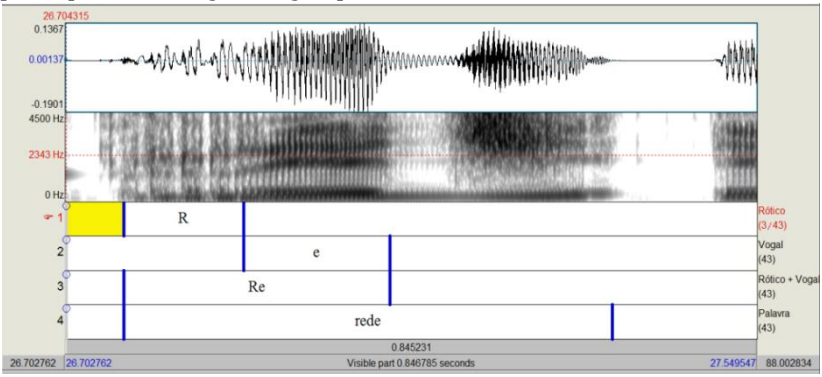
Figure 11 - *The word "rir" (to laugh), produced as [ɣih], by a 26 year-old female participant in the intermediate group.*



Given that fricatives, both velar and glottal, were the rule for the BP productions of most participants, it is expected that they will transfer this variant to English words as well.

Participant 8 in the beginners group produced the rhotic in Portuguese as a trill. The participant was 66 years old and from Rio Grande do Sul. As stated in the review of literature, many speakers, especially elderlies, from that region of the country use this variant. Figure 10 shows the waveform and spectrogram of the word "rasos" produced by participant 8 in the beginners group.

Figure 12 - *The word "rede" (hammock) produced by a 66 year old male participant in the beginners group.*



4.2 PRODUCTION OF ENGLISH RHOTICS

The present study is guided by three research questions. The first one seeks to find out whether beginner and intermediate students produce English rhotic sounds differently. The hypothesis was that intermediate students, for having a higher proficiency level (Osborne, 2008, Silveira, 2012, Zimmer, 2004), would have more target productions than beginners.

The second research question is about the influence of the following vowel on English rhotics. The hypothesis was that, according to Ferraz (2005), the rhotics preceding front vowels would have higher F3 values than those preceding back vowels.

Research question three aims at determining whether the age of onset is related to the production of English rhotic sounds. The hypothesis was that participants with a higher AO would have fewer target productions, as phonetic performance in an L2 tends to decrease when the AO increases (Lima, 2015, Fathman, 1975, as cited in Moyer, 2004).

4.2.1 Research Question 1: Proficiency level

The analysis of the results of the production test in English reveals that there was a difference between both groups. As shown in Table 4 there were only four non-target productions by participants in the intermediate group, made by three different participants, while six of the participants in the beginners group had a total of 28 non-target productions.

Table 5 shows the non-target productions of participants in the beginners group. Among these participants, participant 1 had 3 non-target productions, all for the word "rats", participant 2 had one non-target production for the word "rods", participant 5 had 1 non-target production for the word "rats", participant 6 had three non-target productions for the words "rats" and "rich", and participant 10 had 1 non-target production for the word "rats". All the aforementioned participants produced a fricative variant in place of a retroflex. Participant 8, on the other hand, had only 2 target productions, both for the word "run", and 19 non-target ones.

Table 5 shows the percentages of target productions of both groups. As it can be seen, there is a ceiling effect: although intermediate learners performed better, all participants had between 86% and 100% of correct responses, the only exception was participant number 8.

Table 5 - *Percentages of target productions of beginners and intermediate learners.*

Participant	**Beginners' target productions**	**Intermediate learners' target productions**
1	18 (86%)	21 (100%)
2	20 (95%)	21 (100%)
3	21 (100%)	21 (100%)
4	21 (100%)	21 (100%)
5	20 (95%)	21 (100%)
6	18 (86%)	20 (95%)
7	21 (100%)	21 (100%)
8	2 (9,5%)	21 (100%)
9	21 (100%)	19 (90%)
10	20 (95%)	20 (95%)
	Mean – 16.2 Standard Deviation – 7.83	Mean – 20.6 Standard Deviation – 0.70

Table 6 shows the number of non-target productions by beginner and intermediate learners for each tested word. As can be seen, the

words with the highest number of non-target productions are *"rats"* and *"rich"*.

Table 6 - *Non-target productions of the tested words by beginner and intermediate learners.*

Target Word	Beginners' non target productions	Intermediate learners' non-target productions
Red	3	1
Read	3	0
Rich	5	0
Rods	4	0
Run	1	0
Rats	9	1
Rib	3	2
	Mean - 4 Standard Deviation – 2.52	Mean – 0.57 Standard Deviation - 0.79

As shown in tables 7 and 8, the word that resulted in more non-target productions was "rats". As mentioned in the Review of Literature Chapter, it can be hypothesized that because this word is a cognate in Portuguese, participants tended to produce it with the same variant they use for this word in their mother tongue, hence all the productions using a fricative variant (glottal and velar). Table 6 shows that six beginners had non-target productions, especially P8, who produced a trill for most tokens.

Table 7 - *Target and non-target productions of participants in the beginner group. The non-target productions are highlighted in yellow.*

	Beginners						
Word	*Red*	*Read*	*Rich*	*Rods*	*Run*	*Rats*	*Rib*
P1	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/h/ /h/ /h/	/ɹ/ /ɹ/ /ɹ/
P2	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/h/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P3	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P4	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P5	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/h/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P6	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/h/ /h/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɣ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P7	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P8	/ř/ /ř/ /ř/	/ř/ /ř/ /ř/	/ř/ /ř/ /ř/	/ř/ /ř/ /ř/	/ɹ/ /ř/ /ɹ/	/ř/ /ř/ /h/	/ř/ /ř/ /ř/
P9	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P10	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /h/ /ɹ/	/ɹ/ /ɹ/ /ɹ/

Table 8 shows the target and non-target productions of the participants in the intermediate group. Only three of them had non-target productions, with a total of four non-target productions, in the words

"red", "rats" and "rib". All of the non-target variants were produced as fricatives, both velar and glottal.

Table 8 - *Target and non-target productions of participants in the intermediate group. The non-target productions are highlighted in yellow.*

Intermediate							
Word	*"Red"*	*"Read"*	*"Rich"*	*"Rods"*	*"Run"*	*"Rats"*	*"Rib"*
P1	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P2	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P3	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P4	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P5	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P6	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /h/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P7	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P8	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/
P9	/h/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /h/ /ɹ/
P10	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɹ/ /ɹ/ /ɹ/	/ɣ/ /ɹ/ /ɹ/

As stated in the review of literature chapter, the frequency of F3 of the retroflex variant is usually below 2,000Hz, sometimes going up to 2,100Hz. In the target productions of the participants in this study, especially the beginners, F3 frequencies sometimes exceed such value. That might be an indication that, although participants came very close to the target production, they might not have achieved a native-like pronunciation, that is, the retroflexion of the tongue was not as great as a native speaker´s production. On average, beginners' F3 frequency for the retroflex was 2,189Hz while the intermediate speakers' was within the expected range for a retroflex: 1,950. If we separate the groups into male and female, the average of F3 is 2,134Hz for beginner women 2,070Hz for intermediate women. While for men in the intermediate group, the average of the rhotic´s F3 was 1,741Hz. There were no data for men in the beginners group because they had been excluded due to the poor quality of the recordings.

Table 9 shows the descriptive statistics: in the group of beginners, the mean of target productions was 18.20, while the median was 20. The range is very high – 19. Participant number 8 in this group had only 2 target productions, which accounts for this high variance in the range and the high value of the standard deviation. In the group of intermediate learners, the mean of target productions was 20.6, the median was 21 and the range was only 2, which reflects the fact that most participants got maximum score of correct responses.

Table 9 - *Descriptive statistics of the Mann-Whitney test run for the first research question regarding target productions*

Group	Mean	Median	Standard Deviation	Range
Beginner learners	18.2	20	5.8	19
Intermediate learners	20.6	21	0.70	2

Although there was a difference between the production of the groups, indicating that H1 could be confirmed, statistical analysis shows that the result was not significant. A non-parametric test (Mann-Whitney[12]) was run in order to analyse the two independent groups (beginner and intermediate learners), testing the same variable (number of target productions). The test was chosen because the data were not normally distributed and the sample was small. The hypothesis was unilateral – intermediate learners would have more target productions than beginners. Although the intermediate group scored higher than the beginner group (mean rank 12.3 and 8.7, respectively), the Mann-Whitney value was 32, with an associated probability value (one-tailed) of 0.190 (p), which is not significant.

A correlational test (Spearman's rho[13]) was also run to analyze the correlation between the variables "number of target productions" and "proficiency test score". Table 10 shows the test scores obtained by the two groups of participants. We can see that the scores ranged from 23% to 67% of correct answers. The assumption for the correlational test was unilateral – learners with a higher score in the proficiency test would have more target productions of "r". The value of rho was – 0.077, which shows a very weak and non-significant correlation (p=0.374). Thus, it could be stated that the level of proficiency does not seem to be a good predictor of number of target productions, which is

[12] "The Mann–Whitney and Wilcoxon tests assess whether there is a statistically significant difference between the mean ranks of the two conditions. The Mann-Whitney is used when you have different participants in each condition. The Wilcoxon test is used when you have the same or matched participants in both conditions" (Dancey & Reidy, 2011, p.535)

[13] According to Dancey & Reidy (2011), Spearman's rho is a correlation coefficient, used when data do not comply with the characteristics of a parametric test or when data is not normally distributed. They suggest that when studies count on few participants, researchers should use Spearman´s rho. Thus, that was one of the tests used to answer research question 1.

probably due to the little variation in the score range for the production test.

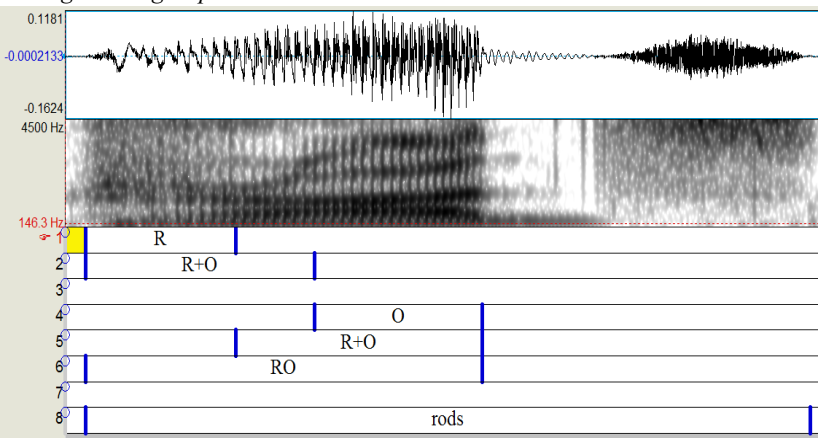
Table 10 - *Participants' proficiency test scores and % of correct responses in the production test.*

Participant	Level of Proficiency	Proficiency Test Score (%)	Target productions (out of 21)
1	1	30	18
2	1	42	20
3	1	23	21
4	1	42	21
5	1	38	20
6	1	43	18
7	1	42	21
8	1	42	2
9	1	47	21
10	1	40	20
1	2	53	21
2	2	52	21
3	2	55	21
4	2	50	21
5	2	67	21
6	2	58	20
7	2	50	21
8	2	50	21
9	2	65	19
10	2	53	20

4.2.1.1 Participant 8 in the beginners group

Participant 8 displayed an interesting pattern of rhotic productions. Among his non-target productions, in the words "rats", "red", "read", "rich", "rods" and "rib", it was possible to see a certain gradience, with traits of trills, taps, fricatives and retroflex variants. Sometimes in the same segment, the participant started producing a fricative, then a trill and finally there is some retroflexion towards the end of the segment. As displayed in figure 13, the waveform shows the presence of characteristics of a trill – the irregular waveform - and also of a fricative – presence of noise - for the orthographic "r" in the word "rods". Moreover, closer to the coarticulation of the rhotic with the vowel, some retroflexion seems to be taking place, with the third formant being separated from the second formant, and having its value around 2,000Hz.

Figure 13 - *The word "rods", produced by a 66 year-old male participant from the beginners' group.*



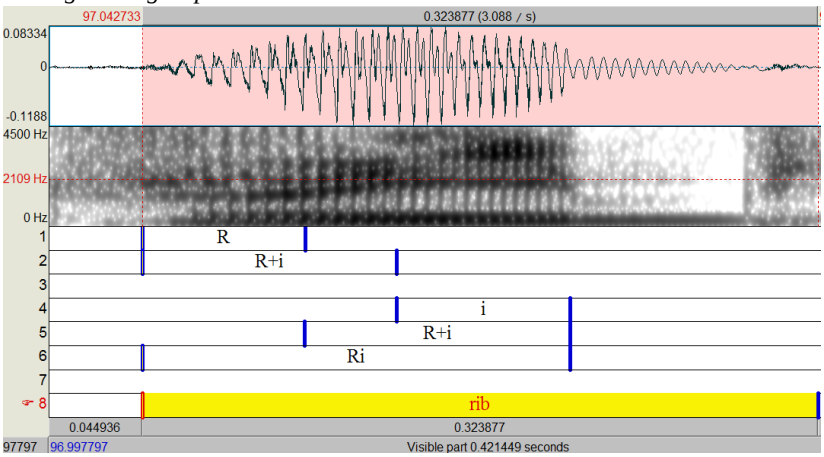
The trill was the variant the participant used in onset position in his mother tongue, which might indicate that the speaker transferred the variant from his L1. Moreover, he was from Rio Grande do Sul, where the trill and the tap are very common variants, but had been living in Florianópolis for many years, where the fricative variants are more used. Besides that, he had been studying English for over two years. Thus, it could be possible that he was transferring the rhotic variants from his original dialect (trill and taps) and mixing them with the variants used in the dialect of his new home (fricatives), while striving to achieve the target pronunciation of English (retroflex).

As mentioned in the Review of Literature chapter, CT posits that form arises from usage and that learners adapt and soft assemble their knowledge of an L2 according to their interactions with the environment. Hence, the gradience in the production of segments in English by participant 8 in the beginners' group could be a result of his experiences with the different dialects of Portuguese (L1 transfer) combined with his new knowledge of the English language, which he had been studying at the time of data collection.

Figure 14 shows the non-target production of the word "rib" by participant 8 in the beginners' group. Machač and Skarnitzl (2009) state that the frequencies of F1, F2 and F3 for the trill are, respectively, approximately 450Hz, between 1,300 and 1,400Hz and slightly above 2,000Hz. In the production shown in figure 6 the frequency of F1 is 461,8Hz, F2 frequency is 1,408Hz, and F3 frequency is 2,109Hz, which

could indicate that the participant was producing a trill. When listening to the production, however, elements of another segment, similar to a retroflex approximant can also be perceived. Furthermore, the values above are also very close to the values of the frequencies of the retroflex approximant, as presented in the Review of Literature chapter. We could conclude, therefore, that the participant had some retroflexion when producing the token, creating a certain gradience for that token as well.

Figure 14 - *The word "rib", produced by a 66 year-old male participant from the beginners group.*



4.2.2 Research Question 2: F3 Values

In order to answer Research Question 2, frequency values of the third formant of the tokens produced as retroflex approximants were extracted. As it has been mentioned, some of the participants' data had to be excluded due to the poor quality of the recordings. Therefore, the beginner group had a total of 8 participants, all women. The intermediate group had a total of 6 participants, 3 women and 3 men. Since the formant frequency is usually lower for men than for women, data were grouped into male and female productions. Thus, the women's group was composed of 11 participants while the men's group had only 3 participants.

For extraction of data, it was considered the productions of vowels each participant had, even if they were not the target pronunciation presented in the sentences. Although there were no

diphthongs in the production test, some of the participants had a non-target pronunciation of some of the vowels, producing a diphthong. Those productions were excluded when answering research question 2. Thus, the front vowels produced were [ɛ], [æ], [i], and [ɪ]. There was only one back vowel, [ɑ].

In order to compare the rhotic's F3 values before front and back vowels when produced by female and male participants, Table 11 displays the F3 medium values for the vowels investigated in the present study as produced by female and male monolingual American speakers (Rauber, 2006).

Table 11 - *Medium F3 values of front and back vowels produced by female and male monolingual American speakers (Rauber, 2006).*

Vowel	Female	Male
[ɛ]	2,846Hz	2,568Hz
[æ]	2,735Hz	2,423Hz
[i]	3,322Hz	2,934Hz
[ɪ]	2,989Hz	2,648Hz
[ɑ]	2,638Hz	2,433Hz

Table 12 shows the productions of women and the values of F3 (Medium and coefficient of variation) of the rhotic before front and back vowels. The lowest rhotic´s F3 values are before the back vowel [ɑ]. As predicted by the hypothesis, the highest F3 value is for the rhotic before the front vowels [i] or [ɪ] – 2,327Hz. Moreover, the rhotic's F3 value before the front vowels [æ] or [ɛ] is also above 2,000Hz (2,055Hz), which is in accordance with Ferraz's (2005) and Rauber's (2006) studies.

Table 12 - *Average F3 values of the retroflex approximant variant before front and back vowels, for female participants' productions*

Retroflex before:	F3 (data interval)	Medium (in Hz) and Coefficient of Variation (%)
[ɑ]	1,412-2,624 Hz	1,926 (7)
[æ] or [ɛ]	1,592-2,714 Hz	2,055 (13)
[i] or [ɪ]	1,914-2,985 Hz	2,327 (10)

Table 13 shows formant values of the rhotic before front and back vowels when produced by male participants. As predicted, formant values are lower for male than for female speakers. Also, F3 values are all below 2,000Hz, which is also in accordance with the productions of

NS, as shown in the Review of Literature. Similar to the productions of female participants, the lowest F3 value is before the back vowel [A] (1,450Hz). The highest F3 value of the retroflex is before the front vowels [i] and [ɪ] (1,963Hz), which offers partial support to hypothesis 2. F3 values before the front vowels [æ] or [ɛ] were 1,769. Thus, the values of the third formant of [ɹ] seem to be in accordance with F3 values of those vowels.

Table 13 - *Average F3 values of the retroflex approximant variant before front and back vowels, for male participants' productions.*

Retroflex before:	**F3 (data interval)**	**Medium (in Hz) and Coefficient of Variation (%)**
[A]	1450-1753 Hz	1,620 (18)
[æ] or [ɛ]	1590-2117 Hz	1,769 (8)
[i] or [ɪ]	1718-2429 Hz	1,963 (9)

Table 14 shows that, the average value of the third formant of the retroflex approximant preceding front vowels in women´s productions was 2,191Hz, while F3 of the rhotic before back vowel was 1,926Hz. That shows a difference of 265Hz. For the 3 male participants, the average of the third formant of the retroflex approximant before front vowels was 1,866Hz, and 1,620Hz before the back vowel, the difference being 246Hz.

Table 14 - *Average F3 values of the retroflex approximant variant before front and back vowels, both for female and male participants' productions.*

	The retroflex's **F3** average value **before front vowels**	The retroflex's **F3** average value **before the back vowel**	Difference
Female	2,191 Hz	1,926Hz	265Hz
Male	1,866 Hz	1,620Hz	246Hz

Those values are in accordance with hypothesis 2, which predicted, according to Ferraz (2005), that the frequency of the third formant of the retroflex approximant is usually higher when adjacent to front vowels. Ferraz (2005) also concluded that the rhotic's F3 adjacent to front vowels usually exceeded 2,000Hz, which in this study was true for the productions by the women's group, but not for the men's group, if we consider the average F3 results only.

Because data were not normally distributed (see appendix G), a non-parametric test (Mann-Whitney) was run in order to check the significance of the results. The variables tested were *Rhotic´s F3 value*

and *Type of neighboring vowel.* The test for the female data shows that the results are significant (Z = -5.056, p = 0.001). The same test was run for the men´s data, and once again, the difference in the rhotic´s F3 values between front and back vowels proved to be significant – Z = -4.076 (p = 0.001). These results allow us to confirm H2: when followed by front vowels, the retroflex´s third formant tends to be higher than when followed by the back vowel.

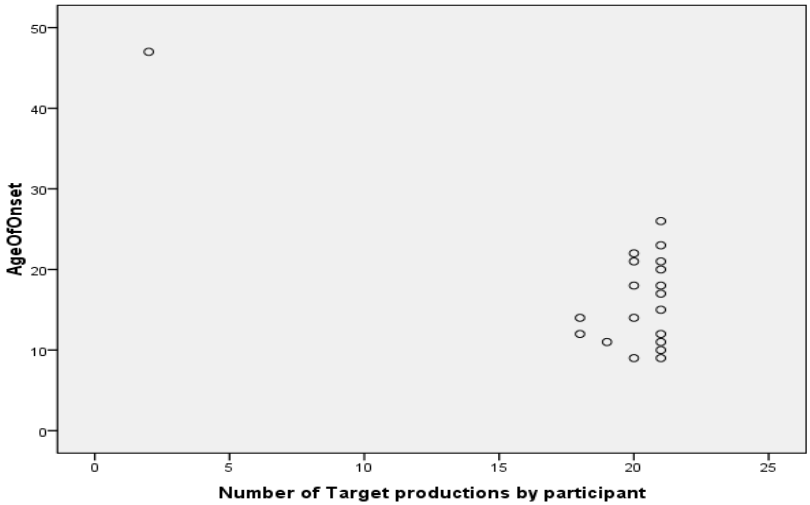
4.2.3 Research Question 3: Age of Onset

As it has already been mentioned, the AO of speakers ranged from 9 to 47, the average being 17.5 years old. The participant who had the most non-target productions (19) was also the one that started learning English at an older age out of all twenty participants: 47 years-old. However, he was also the only one who produced the trill in onset in Portuguese.

In order to test the significance of the correlation of the variables *"Age of Onset"* and *"number of target productions"*, a nonparametric test was run (Spearman´s rho). As already mentioned, this correlational test is used when data is not abundant and not normally distributed, which is the case for the present study.

Figure 15 shows a scattergram of the variables "number of target productions and "age of onset". Once again, it is possible to see the ceiling effect, with only one outlier who had 2 target productions. This participant was the one with the highest AO, however, the sample was too small for a strong correlation to be found between the two variables investigated in Research Question 3, which could not be confirmed.

Figure 15 - *Correlation between the variables "number of target productions" and "age of onset".*



Using a nonparametric correlational test (Spearman's rho), it is possible to conclude that the correlation between the variables *number of target productions* and *age of onset* is very weak (rho = -0.020) and not significant (p=0.467). The mean of the variable "target productions" is 19.40 (standard deviation = 4.2) and the mean for the variable "age of onset" is 17.50 (standard deviation = 1.92).

This chapter has reviewed and answered the 3 Research Questions and their hypothesis. Although not statistically significant, hypothesis 1 can be partially confirmed, as results indicate that the higher the proficiency level, the more target productions of the rhotic were achieved. Hypothesis 2 was confirmed, showing that the frequency of the rhotic's F3 is indeed higher when preceding front vowels than when preceding back vowels. Finally, hypothesis 3 was not confirmed because, although some of the results show the participant with the highest AO also had the highest number of non-target productions, he was the only one behaving in this manner and, therefore, the results were not statistically significant.

When considering the results of the statistical tests and analyzing the data obtained from the production of tokens by participants in the present study, it is important to revisit some of the SLM's (Flege, 1995) aspects. The SLM predicts that L2 speakers do not perceive L2 sounds as monolinguals and that if they identify an L2 sound with an L1 sound,

they will replace them, even if the sounds are phonetically different. It might have been the case that the non-target productions in this study were a result of these factors. Participants may have replaced the orthographic "r" with a fricative in English because that is a possible realization of the phoneme in Brazilian Portuguese.

The SLM also considers that beyond a certain AO (around 12 years-old), it is unlikely that L2 speakers will achieve a native-like pronunciation. Moreover, the SLM also predicts that as AO increases, the probability of distinguishing phonetic differences between sounds in the L1 and the L2 decreases. However, for this study, even the participants with an AO above 12 years of age had very few non-target productions of the rhotic. Table 15 shows the number of non-target productions by participants who had an AO above 12 years-old. Participant 8 in the beginners' group, which has already been discussed above, was the one with the most non-target productions (18). Only one participant in the beginner´s group had three non-target productions, four participants had one non-target production and seven had no non-target productions. Although sample size was not very large to make results significant and as there was a ceiling effect, it is possible that even late learners may acquire the L2 phonological system, as predicted by Epstein, Fynn and Martohardjono (1996).

Table 15 - *Number of non-target productions and AO of participants.*

Participant's proficiency level	Age of Onset	Number of non-target productions
1	14	3
1	22	1
1	20	0
1	17	0
1	18	1
1	47	18
1	18	0
2	15	0
2	23	0
2	26	0
2	21	1
2	21	0
2	14	1

As described in the Review of Literature, Complexity Theory predicts that form arises from usage and that language is an open system, which means that the productions of participants are a result of

their interaction with teachers, classmates, movies, music, among other factors, and all of that knowledge is always being adapted to fit their needs. Perhaps for speakers who start using a non-target realization of a phoneme and never have anyone correct it, this type of pronunciation is likely to become permanent in their L2 speech.

It is also imperative to mention the *butterfly effect* described by CT in the Review of Literature chapter. All the individual factors such as motivation, trips, exposure to L2, readings may influence the way speakers develop their phonological system in the L2. The participants in this study had different motivations for studying English – as a hobby, to be able to travel to English speaking countries, to speak the language at work or to have access to more information both for leisure and study purposes. Moreover, their practice of and exposure to the L2 was varied – language courses, watching movies and TV series, reading books, articles, talking to colleagues and friends, and listening to music. Therefore it is very difficult to measure the extent to which these factors affect speakers' productions, but they all have an influence in the acquisition process.

Finally, CT describes a process of *imitation* by L2 speakers, in which they merge old and new forms, always adapting to fit situations. In the case of participant 8 in the beginners' group, it could be hypothesized that the gradience he presented in his productions are a result of *soft assembly* caused by the different accents he was exposed to in Brazilian Portuguese – he lived in Rio Grande do Sul, where the pronunciation of the rhotic in onset can be a trill, especially among older speakers, and in Santa Catarina, where its pronunciation is usually a fricative variant.

Next, I present the conclusion, the limitations and the pedagogical implications of the present study.

CHAPTER 5 - CONCLUSION

5.1 LIMITATIONS OF THE STUDY AND AVENUES FOR FUTURE RESEARCH

As already mentioned previously, the greatest limitation of this research was the small number of participants. As shown in the Review of Literature, studies by Silveira (2012) and Zimmer (2004) on coda production had results that supported the prediction made in H1, which hypothesized a significant effect of proficiency level on the production of rhotics in onset position. Zimmer's (2004) study counted on 156 participants, and Silveira's (2012) on 31. Therefore, for future studies, I would recommend increasing the number of participants so that results may have a better chance at achieving significance.

Insufficient data were also a limitation for answering research question 2. Many participants' data had to be excluded because of the poor quality of the recordings. Some participants' data had been recorded in a quiet room, but even so the sound quality was poor for acoustic analysis. That made it very difficult for data to be analyzed and therefore, the researcher made the decision of not using those tokens. Thus, it is crucial for any study carrying out analysis to count on data recorded in a soundproof cabin.

Moreover, using a more qualitative test, such as an interview, might have generated different and more significant results than a sentence reading task.

5.2 PEDAGOGICAL IMPLICATIONS

Albeit, the results of Research Question 3 were not significant to confirm that learners with a lower AO had more target productions, there was still an indication of what has been mentioned in the Review of Literature: the earlier we start learning an L2, the better because the chances of being more accurate are also higher. Therefore, I believe that, especially in Brazil, the way foreign languages are taught in schools should be modified, giving greater emphasis to conversation, not only grammar. Thus, providing students with a more naturalistic way to learn a foreign language at an early age would be more effective.

The results of the present research, especially those of Research Question 2, which look into the value of the third formant of the retroflex, show that not all participants in the study were able to produce the variant within the expected values (under 2,000Hz). This might be a

consequence of L1 transfer and acquisition after the sensitive period for some participants, as it has already been mentioned (Flege, 1995).

As the SLM posits, distinguishing phonetic differences between sounds of the L1 and the L2 becomes a more difficult task as AO increases. Furthermore, some participants in the study replaced the target pronunciation of the rhotic (retroflex) with a fricative variant, which may have been because in their L1, Brazilian Portuguese, the orthographic "r" may be pronounced as both, with no change in meaning. Therefore, Brazilian students could benefit from specific instruction on rhotics.

Another important point to make is that as predicted in CT, learners tend to favor the use of some forms over others. I believe sometimes the use of non-target phonetic segments in the L2 becomes somewhat rooted in speakers' phonological system, and it is very challenging to change that. In the case of "r" in onset position, it might be the case that learners cannot distinguish the difference between the retroflex and the fricative because, for them, both sounds represent the same phoneme, and they end up using the one (many times the non-target production) that they are more used to using in the L1, and this type of L1 transfer may sometimes lead to miscommunication.

Since the results of this study show that Brazilian learners tend to have difficulties pronouncing the rhotic sounds in English, perhaps through specific instruction and enough exposure to the L2, they can come to adapt their knowledge, which, as CT posits, involves merging old and new forms, and eventually end up using target productions of phonemes in the L2.

As for AO, as Flege (1995) concludes, the ideal situation is for a learner to start learning the L2 as a young child, especially in the acquisition of the phonological system. However, it is possible for late learners to attain fluency, and older children and adults may achieve good results, even in learning the phonology of the L2.

5.3 FINAL CONSIDERATIONS

Although the results were not statistically significant to confirm H1, they can still be seen an indicator that the higher the proficiency level, the better pronunciation learners will present in the L2, since only 3 participants in the intermediate group had no non-target pronunciations, two of which had only 1, contrary to the beginners' group, in which 6 participants displayed non-target productions.

Albeit most participants had target-like pronunciations of the segment investigated in the present study, the analysis of formant frequencies shows that they were not native-like. This seems to be in accordance with Granena and Long's (2013) findings, which state that it is very rare for a learner to achieve native-like pronunciation beyond an AO of 12 – only 3 participants in this study had an AO below 12. If we take Flege, Munro and Mackay's (1995) study with native Italian learners of English, the native-like productions of the "r" were only achieved by participants with an AO below 10. Therefore, it is possible to state that, for the purpose of pronunciation accuracy, the earlier learners begin studying an L2, the better. However, it is not impossible to acquire an L2 beyond the sensitive period, which happens around the age of 12, as already mentioned. The literature and teachers' experience are filled with examples, although they are not the rule.

As mentioned in the Review of Literature, intelligibility is what listeners understand from speakers' speech, and, in my understanding, it should be the goal for L2 learning, rather than native-like production. As it could be seen from the results of this study, it was very rare for participants to achieve native-like pronunciation. Most of them came very close to producing a retroflex approximant for the orthographic "r" in English, but formant frequencies showed that sometimes they were not native-like. Nonetheless, they were considered as target productions, which means they would be expected to be understood by listeners (high intelligibility level). I believe that it is the case for most L2 speakers – who have an AO beyond the sensitive period – native-like pronunciation is very unlikely. Yet, when the segment is produced similarly to the native pronunciation and there is no risk of the word sounding like a different one, it should be considered appropriate.

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APPENDIX

APPENDIX A – CONSENT FORM

Formulário de Autorização
Universidade Federal de Santa Catarina (UFSC)
Centro de Comunicação e Expressão
Pós Graduação em Inglês – Estudos Linguísticos e Literários

FORMULÁRIO DE AUTORIZAÇÃO PARA PARTICIPAÇÃO EM PESQUISA

Prezado participante,

Meu nome é Soraia Morgan e sou mestranda da pós gradução em inglês da UFSC. Gostaria de convidá-lo a participar de minha coleta de dados. Infelizmente, os objetivos específicos da pesquisa não podem ser revelados uma vez que poderiam interferir no seu desempenho e, assim, nos resultados. Porém, é possível informar que os dados coletados podem servir para a elaboração e melhoria de materiais didáticos, adequando-os às necessidades dos alunos brasileiros aprendizes de inglês e, também, contribuindo para o ensino nas áreas de Fonética e Fonologia de modo geral.

Procedimentos:

Se você optar por participar da pesquisa, uma data, hora e local convenientes para você serão marcados para os procedimentos que serão descritos a seguir. Você tem total liberdade e pode levar o tempo que precisar para pensar sobre a proposta.

Como participante voluntário deste estudo, você fará um teste de proficiência na língua inglesa (Oxford, 2004), responderá a um questionário e realizará um teste de produção. O teste de produção consistirá na leitura de algumas frases em português e outras em inglês. As informações contidas no questionário irão direcionar as análises dos dados da pesquisa, mas **os nomes dos participantes não serão divulgados**, uma vez que se trata de uma pesquisa de cunho quantitativo. Os resultados daqui obtidos serão a base de minha dissertação, a ser defendida em junho de 2017 e o estudo tornar-se-á público.

Os riscos ou desconfortos associados à sua participação são mínimos, limitando-se a possível cansaço mental e ansiedade ao efetuar

as gravações. Para minimizar essa situação, você poderá optar por fazer pequenas pausas durante o procedimento de coleta. As informações fornecidas e o material coletado serão absolutamente confidenciais e não haverá identificação nominal dos participantes, nem divulgação de quaisquer informações que possam revelar sua identidade. O participante pode, a qualquer momento e sem qualquer penalização, deixar de participar da pesquisa, informando o pesquisador de sua decisão, a fim de que ele não utilize mais os dados do desistente.

Asseguro que esta pesquisa está submetida aos critérios da Resolução 466/2012 e suas complementares e tem aprovação do CEPSH/UFSC (endereço e telefone abaixo). Este Termo de Consentimento Livre e Esclarecido será impresso em duas vias assinadas e rubricadas, ficando uma em seu poder. Ao assinar esse consentimento, você está autorizando a gravação de sua voz e a publicação dos resultados em minha dissertação de mestrado e possíveis futuras publicações como artigos e trabalhos acadêmicos.

A participação nesta pesquisa não acarreta, de forma alguma, em prejuízos ou em privilégios. Se porventura existirem, por mínimas que sejam, qualquer tipo de despesas tidas pelos participantes da pesquisa e dela decorrentes, conforme item IV 3 (g) da Resolução 466/2012 haverá garantia de ressarcimento dos gastos pelo pesquisador responsável, bem como indenização diante de eventuais danos oriundos também da pesquisa. Se houver quaisquer dúvidas referentes ao seu desenvolvimento, a pesquisadora está à disposição para esclarecimentos através dos contatos dispostos abaixo.

Eu, _____, Carteira de Identidade (ou passaporte) número _____, concordo em participar deste estudo e autorizo o pesquisador a utilizar os dados por mim fornecidos.

_____ _____

Assinatura da pesquisadora Assinatura do participante

Florianópolis, ____ / ____/ _____

Contatos:

Pesquisadora: Endereço: Rua Joaquim Nabuco, 1737. Ap 102. Capoeiras.

Email/telefone: soraia.morgan@gmail.com / (48) 9632-7634

Pesquisadora responsável: rosane@cce.ufsc.br / (48) 9615-9978

Comitê de Ética em Pesquisa com Seres Humanos (CEPSH-UFSC)
Email: cep.propesq@contato.ufsc.br
Endereço: Rua Desembargador Vitor Lima, nº 222. 4º andar, sala 401
Telefone para contato: 3721-6094

APPENDIX B – QUESTIONNAIRE FOR PARTICIPANTS

Questionário para participantes do teste de produção

1. Nome: _____
2. Idade: _____

3. Assinale a resposta mais adequada:
( ) Sempre morei em Florianópolis.
( ) Também morei em _____ por ( ) meses/ ( ) anos.
( ) Também morei em _____ por ( ) meses/ ( ) anos.
( ) Também morei em _____ por ( ) meses/ ( ) anos.
( ) Também morei em _____ por ( ) meses/ ( ) anos.
( ) Também morei em _____ por ( ) meses/ ( ) anos.

4. Com que idade você começou a aprender inglês? Especifique se isso aconteceu mais de uma vez e onde (escola, cursos de idiomas, intercâmbio, etc).
_____
_____

5. Você já morou em algum país de língua inglesa? Se sim, especifique onde, por quanto tempo e quais atividades exerceu nesse país durante o tempo em que lá viveu.
País: _____
Tempo de permanência: _____ ( )meses ( )anos.
Atividade: _____
País: _____
Tempo de permanência: _____ ( )meses ( )anos.
Atividade: _____
País: _____
Tempo de permanência: _____ ( )meses ( )anos.
Atividade: _____

6. Assinale a resposta mais adequada em relação à sua experiência de estudos da língua inglesa:
( ) Já fiz cursos de idiomas por _____ ( )meses ( )anos.
( ) Já fiz aula particular por _____ ( )meses ( )anos.
( ) Já fiz aulas no curso extracurricular da UFSC por____
( )meses ( )anos.
( ) Outros. Especifique: _____

7. Quantas horas por semana você dedica ao estudo do inglês atualmente? (fora da sala de aula) _____horas.

8. Você gosta de inglês?
( ) Sim ( ) Não

9. Você pratica a língua fora da sala de aula? Como? Especifique como.

( ) Sim ( ) Não
( ) Assisto à filmes e/ou seriados em inglês.
( ) Ouço música em inglês.
( ) Pratico conversando com amigos e/ou colegas.
( ) Outros. Especifique _____

10. Por que você estuda inglês? Especifique.
( ) Por hobby.
( ) Preciso para os meus estudos.
( ) Preciso para o meu trabalho.
( ) Outros. Especifique: _____

APPENDIX C – PRODUCTION TESTS IN THE PILOT STUDY

Production Test – Rhotics in onset position

Sentences will be read 3 times each, in random order. They will be presented in a different order to each participant.

Portuguese

1. Pegue pratos fundos, rasos e copos.
2. Compramos ganchos, rede e parafusos.
3. O que é isso: riso ou gargalhada?
4. Eu já disse: roxo fica bonito em você!
5. O comentário foi desnecessário, rude e ignorante.
6. Ele me disse: rir é o melhor remédio.
7. As crianças precisam de lápis, régua e borracha.

English

1. What do you prefer: rap or blues?
2. I told you: read that book!
3. They are nice, rich, and polite people.
4. I want John, Rob, and Mary to come.
5. She prefers to swim, run, and dance.
6. They like to play cards, read and cook.
7. He broke his leg, rib and arm.

APPENDIX D – PRODUCTION TESTS

Production Test – Rhotics in onset position

Sentences will be read 3 times each, in random order. They will be presented in a different order to each participant.

Portuguese

8. Pegue pratos fundos, rasos e copos.
9. Compramos ganchos, rede e parafusos.
10. O que é isso: riso ou gargalhada?
11. Eu já disse: roxo fica bonito em você!
12. O comentário foi desnecessário, rude e ignorante.
13. Ele me disse: rir é o melhor remédio.
14. As crianças precisam de lápis, régua e borracha.

Distractor

In the afternoon, Jane likes to eat different fruits. She eats oranges, apples, grapes or melon.

After eating the fruits, Jane sleeps a little. Then she studies for about 2 hours before going to class at night. Jane likes to study a lot. She wants to be a professor.

English

8. Which do you prefer: red
9. I told you: read that book!
10. They are nice, rich, and smart people.
11. I need to buy nails, rods, and paint.
12. She prefers to swim, run, and dance.
13. They had birds, rats, and dogs.
14. He broke his leg, rib, and arm.

APPENDIX E – SCRIPT (GERA TABELAS)

```
# Geracao de tabela com frequencias formantes
# Entrada:
#   arquivo .wav
#   arquivo .TextGrid com marcacao de segmentos a serem analisados
# Processamento:
#   Analise de formantes no arquivo .wav original
#   Analise de intensidade no arquivo .wav original
#   Selecao de 3 pontos de analise em cada segmento
#   Extracao da intensidade em cada um dos pontos
#   Extracao de F1, F2 e F3 em cada um dos pontos
# Saida:
#   Arquivo no formato txt (campos separados por tabulacao)
#     com dados obtidos no processamento
#   Nome do arquivo de saida eh igual ao de entrada, com extensao .txt
#
# Fernando S. Pacheco
# LINSE/UFSC
#
nFORMANTES=5
#a linha acima corresponde ao número de formantes que a análise vai
apresentar: F1, F2, F3, F4, F5
nPONTOS=3
#a linha acima corresponde ao número de pontos que ele vai pegar pra
cada segmento
select all
if numberOfSelected() > 0
Remove
endif
form Arquivo a processar (extração de formantes)
word Folder_(Diretório) D:\Sandra\int_audio\
word File_(Arquivo_áudio_com_extensão) teste1.wav
endform
#folder$=""
#file$="teste1.wav"
fil$ = folder$ + file$
Read from file... 'fil$'
filename$ = selected$ ("Sound")
filegrid$ = filename$ + ".TextGrid"
filegrid$ = folder$ + filegrid$
```

```
Read from file... 'filegrid$'
select Sound 'filename$'
To Formant (burg)... 0.0 5 4500 0.025 50
select Sound 'filename$'
To Intensity... 100 0.0 no
select Sound 'filename$'
plus TextGrid 'filename$'
Extract non-empty intervals... 1 yes
#o número que aparece na linha acima corresponde ao tier, para buscar os dados no tier 1, coloque 1 e assim por diante
nselected = numberOfSelected ("Sound")
#nao vou mais precisar do arquivo de audio
select Sound 'filename$'
plus TextGrid 'filename$'
Remove
#
#limpar janela info
Clearinfo

printline N_SEG; NOME; DUR(s); INST_ANALISE(s); INTENSID(dB); F1(Hz); F2(Hz); F3(Hz); INST_ANALISE(s); INTENSID(dB); F1(Hz); F2(Hz); F3(Hz); INST_ANALISE(s); INTENSID(dB); F1(Hz); F2(Hz); F3(Hz)

#contador de segmentos
i = 1
while i <= nselected
select all
soundID = selected ("Sound", 'i')
select 'soundID'
nomeseg$ = selected$ ("Sound")
tp_ini = Get starting time
tp_fim = Get finishing time
duracao = Get total duration

#definicao dos pontos de analise
#inicio do segmento
tp1 = tp_ini
#meio do segmento
```

```
tp2 = (tp_ini+tp_fim)/2
#fim do segmento
tp3 = tp_fim

#Os formantes são obtidos a partir do arquivo original e não de cada
segmento. Assim, evita-se o problema com as bordas dos segmentos
for k from 1 to nPONTOS
tp_analise = tp'k'
if k == 1
print 'i"tab$' 'nomeseg$' 'tab$' 'duracao' 'tab$' 'tp_analise'
else
print 'tab$' 'tp_analise'
endif
for n from 1 to nFORMANTES
select Formant 'filename$'
fn = Get value at time... 'n' 'tp_analise' Hertz Linear
select Intensity 'filename$'
in = Get value at time... 'tp_analise' Cubic
#separacao seguinte entre 1o. e outros formantes apenas para formatacao
na impressao
if n == 1
print 'tab$' 'in' 'tab$' 'fn'
else
print 'tab$' 'fn'
endif
#n = numero do formante
#tp = tempo
endfor
endfor
print 'newline$'
i=i+1
endwhile
#criar arquivo de saida
#tabela no formato cvs
fileout$ = folder$ + filename$ + ".txt"
#apaga arquivo (se existente)
filedelete 'fileout$'
#copia conteudo da janela info para o arquivo
fappendinfo 'fileout$'
```

APPENDIX F - STATISTICAL TESTS RESEARCH QUESTION 1

Descriptive Statistics

	N	Mean	Std. Deviation	Minimum	Maximum
Number of Target Productions	20	19,40	4,210	2	21
Level of Proficiency of each participant	20	1,50	,513	1	2

Ranks

	Level of Proficiency of each participant	N	Mean Rank	Sum of Ranks
Number of Target Productions	1	10	8,70	87,00
	2	10	12,30	123,00
	Total	20		

Test Statistics[b]

	Number of Target Productions
Mann-Whitney U	32,000
Wilcoxon W	87,000
Z	-1,504
Asymp. Sig. (2-tailed)	,133
Exact Sig. [2*(1-tailed Sig.)]	,190[a]

a. Not corrected for ties.

b. Grouping Variable: Level of Proficiency of each participant

Correlations

	Number of Target Productions	Score

Spearman's rho	Number of Target Productions	Correlation Coefficient	1,000	-,077
		Sig. (1-tailed)	.	,374
		N	20	20
	Score	Correlation Coefficient	-,077	1,000
		Sig. (1-tailed)	,374	.
		N	20	20

Descriptives

	Level of Proficiency of each participant		Statistic	Std. Error
Number of Target Productions	1 Mean		18,20	1,837
	95% Confidence Interval for Mean	Lower Bound	14,05	
		Upper Bound	22,35	
	5% Trimmed Mean		18,94	
	Median		20,00	
	Variance		33,733	
	Std. Deviation		5,808	
	Minimum		2	
	Maximum		21	
	Range		19	
	Interquartile Range		3	
	Skewness		-2,939	,687
	Kurtosis		8,924	1,334
	2 Mean		20,60	,221
	95% Confidence Interval for Mean	Lower Bound	20,10	

	Upper Bound	21,10	
5% Trimmed Mean		20,67	
Median		21,00	
Variance		,489	
Std. Deviation		,699	
Minimum		19	
Maximum		21	
Range		2	
Interquartile Range		1	
Skewness		-1,658	,687
Kurtosis		2,045	1,334

Extreme Values

	Level of Proficiency of each participant			Case Number	Value
Number of Target Productions	1	Highest	1	3	21
			2	4	21
			3	7	21
			4	9	21
			5	2	20[a]
		Lowest	1	8	2
			2	6	18
			3	1	18
			4	10	20
			5	5	20[b]
	2	Highest	1	11	21
			2	12	21
			3	13	21

		4	14	21
		5	15	21[c]
	Lowest	1	19	19
		2	20	20
		3	16	20
		4	18	21
		5	17	21[d]

a. Only a partial list of cases with the value 20 are shown in the table of upper extremes.

b. Only a partial list of cases with the value 20 are shown in the table of lower extremes.

c. Only a partial list of cases with the value 21 are shown in the table of upper extremes.

d. Only a partial list of cases with the value 21 are shown in the table of lower extremes.

APPENDIX G - STATISTICAL TESTS RESEARCH QUESTION 2

Women´s data

TypeOfVowel

Case Processing Summary

		Cases					
		Valid		Missing		Total	
	TypeOfVowel	N	Percent	N	Percent	N	Percent
F3Values	Front Vowel	145	100,0%	0	,0%	145	100,0%
	Back Vowel	30	100,0%	0	,0%	30	100,0%

Descriptives

TypeOfVowel				Statistic	Std. Error
F3Values	Front Vowel	Mean		2221,90	23,098
		95% Confidence Interval for Mean	Lower Bound	2176,25	
			Upper Bound	2267,56	
		5% Trimmed Mean		2217,78	
		Median		2228,00	
		Variance		77357,893	
		Std. Deviation		278,133	
		Minimum		1592	
		Maximum		2985	
		Range		1393	
		Interquartile Range		341	
		Skewness		,193	,201
		Kurtosis		,135	,400

	Back Vowel	Mean	1926,22	50,852
		95% Confidence Interval for Mean — Lower Bound	1822,21	
		95% Confidence Interval for Mean — Upper Bound	2030,22	
		5% Trimmed Mean	1916,11	
		Median	1860,25	
		Variance	77577,752	
		Std. Deviation	278,528	
		Minimum	1413	
		Maximum	2624	
		Range	1212	
		Interquartile Range	251	
		Skewness	,996	,427
		Kurtosis	1,592	,833

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	TypeOfVowel	Statistic	df	Sig.	Statistic	df	Sig.
F3Values	Front Vowel	,050	145	,200*	,991	145	,488
	Back Vowel	,168	30	,030	,882	30	,003

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

NPar Tests

Mann-Whitney Test

Ranks

	TypeOfVowel	N	Mean Rank	Sum of Ranks
F3Values	Front Vowel	145	96,81	14037,00

	Back Vowel	30	45,43	1363,00
	Total	175		

Test Statistics[a]

	F3Values
Mann-Whitney U	898,000
Wilcoxon W	1363,000
Z	-5,056
Asymp. Sig. (2-tailed)	,000

a. Grouping Variable: TypeOfVowel

Men´s data

Descriptives

	VowelType			Statistic	Std. Error
F3Values	Front Vowel	Mean		1891,02	28,600
		95% Confidence Interval for Mean	Lower Bound	1833,30	
			Upper Bound	1948,74	
		5% Trimmed Mean		1879,32	
		Median		1834,36	
		Variance		35172,252	
		Std. Deviation		187,543	
		Minimum		1591	
		Maximum		2430	
		Range		839	
		Interquartile Range		269	
		Skewness		,819	,361

	Kurtosis		,598	,709
Back Vowel	Mean		1620,87	30,022
	95% Confidence Interval for Mean	Lower Bound	1551,64	
		Upper Bound	1690,10	
	5% Trimmed Mean		1622,98	
	Median		1633,75	
	Variance		8111,766	
	Std. Deviation		90,065	
	Minimum		1450	
	Maximum		1753	
	Range		303	
	Interquartile Range		131	
	Skewness		-,583	,717
	Kurtosis		,450	1,400

Tests of Normality

		Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	VowelType	Statistic	df	Sig.	Statistic	df	Sig.
F3Values	Front Vowel	,130	43	,064	,946	43	,041
	Back Vowel	,181	9	,200*	,968	9	,874

a. Lilliefors Significance Correction

*. This is a lower bound of the true significance.

Mann-Whitney Test

Ranks

	VowelType	N	Mean Rank	Sum of Ranks
F3Values	Front Vowel	43	30,42	1308,00
	Back Vowel	9	7,78	70,00

Ranks

	VowelType	N	Mean Rank	Sum of Ranks
F3Values	Front Vowel	43	30,42	1308,00
	Back Vowel	9	7,78	70,00
	Total	52		

Test Statistics[b]

	F3Values
Mann-Whitney U	25,000
Wilcoxon W	70,000
Z	-4,076
Asymp. Sig. (2-tailed)	,000
Exact Sig. [2*(1-tailed Sig.)]	,000[a]

a. Not corrected for ties.

b. Grouping Variable: VowelType

APPENDIX H - STATISTICAL TESTS RESEARCH QUESTION 3

Nonparametric Correlations

Correlations

			Number of Target productions by participant	AgeOfOnset
Spearman's rho	Number of Target productions by participant	Correlation Coefficient	1,000	-,020
		Sig. (1-tailed)	.	,467
		N	20	20
	AgeOfOnset	Correlation Coefficient	-,020	1,000
		Sig. (1-tailed)	,467	.
		N	20	20

APPENDIX I - PARECER CONSUBSTANCIADO DO CEP

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: A Produção dos Sons Róticos em Inglês por Falantes Brasileiros

Pesquisador: Rosane Silveira **Área Temática:**

Versão: 4

CAAE: 46910715.5.0000.0121

Instituição Proponente:UNIVERSIDADE FEDERAL DE SANTA CATARINA **Patrocinador Principal:** Financiamento Próprio

DADOS DO PARECER Número do Parecer: 1.466.601

Apresentação do Projeto:
Trata-se de um Projeto de Pósgraduação do Centro de Comunicação e Expressão -Pós Graduação em
Inglês- Estudos linguisticos e Literários da UFSC, E intitulado A
Produção dos Sons Róticos em Inglês por Falantes Brasileiros Desenho:
O estudo contará com a participação de 20 estudantes brasileiros de inglês. 10 de nível iniciante e 10 de nível intermediário. Os participantes farão um teste de proficiência, responderão a um questionário com informações relevantes ao estudo e farão um teste de produção.Essas informações incluem nome, idade, lugares onde morou e por quanto tempo, com que idade começou a aprender a língua, se já morou em algum país de língua inglesa e por quanto tempo, que tipo de instrução já teve na língua e por quanto tempo, quantas horas por semana e como se dedica ao estudo da língua por semana fora da sala de aula, se gosta de inglês e quais
suas motivações para estudar a língua. O teste de produção consistirá na leitura de 7 frases (que serão repetidas 3x cada) em português e de 7 frases (que também serão repetidas 3x cada) em inglês. Após aassinatura do termo de consentimento e de ter feito o teste de proficiência, os participantes serãoconvidados comparecer ao laboratório de fonética da UFSC, em uma data e hora convenientes para gravar os dados do teste de produção.

Objetivo da Pesquisa:
Objetivo Primário:
O principal objetivo deste estudo é investigar a produção dos sons róticos em posição de ataque por alunos brasileiros iniciantes e intermediários

Avaliação dos Riscos e Benefícios:
Riscos:
Os riscos para os participantes são: - não sentir-se à vontade ao responder algumas perguntas pessoais do questionário como por exemplo sua idade, a idade com a qual começou a estudar inglês, os lugares em que morou e até se gosta ou não de estudar a língua;- ao fazer o teste de proficiência os participantes podem se sentir cansados ou estressados para obter um bom resultado;- ao fazer o teste de produção, os participantes podem sentir-se constrangidos na leitura das frases em inglês em frente à pesquisadora, também podem sentir-se cansados.
Benefícios:
Embora haja estudos sobre a produção dos róticos no inglês por falantes de português brasileiro (e.g., Osborne, 2008, 2010, Deus, 2009, Schadech, 2013), ainda há espaço para uma contribuição sólida da análise acústica nos estudos de fonologia para descrever a natureza dos sons da segunda língua

Comentários e Considerações sobre a Pesquisa:
O Projeto de pesquisa demonstra pertinência teórica e metodológica com condições de ser desenvolvido na prática

Considerações sobre os Termos de apresentação obrigatória:
O pesquisador apresentou a documentação exigida para submissão e avaliação do CEPSH UFSC; Projeto, Relatório, Folha de Rosto, TCLE, Cronograma, Orçamento, Carta Declaração Instituição

Recomendações:
Sem recomendações.

Conclusões ou Pendências e Lista de Inadequações:
Concluo indicando aprovação pois o pesquisador atendeu a todas as pendências indicadas pelo relator.

Considerações Finais a critério do CEP:

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_526227.pdf	16/03/2016 22:03:48		Aceito
Outros	carta_resposta_pendencias_marco.docx	16/03/2016 22:03:30	Rosane Silveira	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	Consent_Form_Marco.docx	16/03/2016 22:03:03	Rosane Silveira	Aceito
Outros	declaraçãoSoraia.pdf	07/07/2015 16:50:18		Aceito
Folha de Rosto	folhaderostoJunho.pdf	24/06/2015 13:34:59		Aceito
Projeto Detalhado / Brochura Investigador	Projeto Traduzido.docx	01/06/2015 09:03:49		Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

FLORIANOPOLIS, 28 de Março de 2016

Assinado por:
Washington Portela de Souza
(Coordenador)