THE ACQUISITION OF FINE PHONETIC DETAIL IN A FOREIGN LANGUAGE:
PERCEPTION AND PRODUCTION OF STOPS IN
L2 ENGLISH AND L1 PORTUGUESE

by

Denise Maria Osborne

Copyright © Denise Maria Osborne 2016

A Dissertation Submitted to the Faculty of the

GRADUATE INTERDISCIPLINARY DOCTORAL PROGRAM IN
SECOND LANGUAGE ACQUISITION AND TEACHING

In Partial Fulfillment of the Requirements

For the Degree of

DOCTOR OF PHILOSOPHY

In the Graduate College

THE UNIVERSITY OF ARIZONA

2016
As members of the Dissertation Committee, we certify that we have read the dissertation prepared by Denise Maria Osborne, titled The Acquisition of Fine Phonetic Detail in a Foreign Language: Perception and Production of Stops in L2 English and L1 Portuguese and recommend that it be accepted as fulfilling the dissertation requirement for the Degree of Doctor of Philosophy.

Date: June 4, 2016
Miquel Simonet

Date: June 4, 2016
Ana Carvalho

Date: June 4, 2016
Natasha Warner

Final approval and acceptance of this dissertation is contingent upon the candidate’s submission of the final copies of the dissertation to the Graduate College.

I hereby certify that I have read this dissertation prepared under my direction and recommend that it be accepted as fulfilling the dissertation requirement.

Date: June 4, 2016
Dissertation Director: Miquel Simonet
STATEMENT BY AUTHOR

This dissertation has been submitted in partial fulfillment of the requirements for an advanced degree at the University of Arizona and is deposited in the University Library to be made available to borrowers under rules of the Library.

Brief quotations from this dissertation are allowable without special permission, provided that an accurate acknowledgement of the source is made. Requests for permission for extended quotation from or reproduction of this manuscript in whole or in part may be granted by the head of the major department or the Dean of the Graduate College when in his or her judgment the proposed use of the material is in the interests of scholarship. In all other instances, however, permission must be obtained from the author.

SIGNED: Denise Maria Osborne
ACKNOWLEDGMENTS

I would like to start by thanking each member of my committee, Dr. Miquel Simonet, Dr. Natasha Warner, and Dr. Ana Carvalho. First, my special thanks to Professor Simonet, who guided and advised me, from the beginning to the end of this study. I am thankful for his support, and especially grateful for the times he pushed me to do my best. I am also thankful that he was able to obtain the stimuli for the perception study from the researchers Gonzales and Lotto; without these stimuli, this research could not have been undertaken. Professor Simonet’s influence on my academic life goes beyond the present study. It was with him that I first learned how to use Praat, and with whom I designed my first experiments. Although for a great part of my research I was not physically present for our regular meetings at the University of Arizona, Professor Simonet was always willing to meet me through Skype or to exchange emails. I am very grateful to him. Thank you, Professor Simonet!

Second, I would like to thank Professor Natasha Warner. It was with Professor Warner that I learned about the wonders of phonetics; it was with her enthusiasm for teaching and research that I became motivated to follow my passion for L2 sounds. It was also with her that I learned the daunting subject of statistics! Professor Warner generously invited me to use one of the rooms in the Phonetics Lab and to participate in the weekly lab meetings. I then had the opportunity to connect with other colleagues who had the same interests, which later turned out to be important for my research. Thank you, Professor Warner!

Third, my special thanks to Professor Ana Carvalho. Professor Carvalho was (and has been) very important both in my research and teaching career. Among all her qualities as an advisor, I truly admire her ability to “bring us to reality” regarding our always ambitious research
dreams. Her experience as a researcher and her knowledge of Portuguese linguistics have been crucial for the success of my dissertation research. It was with Professor Carvalho that I learned Portuguese phonology and phonetics. Her love for the topic was contagious and increased my love for the area, ensuring that phonetics was the area that I would pursue as a Ph.D. student. I also would like to thank Professor Carvalho for her guidance during the four years I taught Portuguese at the University of Arizona. I was always surprised by Professor Carvalho’s expertise; there is always something new and original that I learn from her. Professor Carvalho’s guidance has shaped my career as a Portuguese instructor and as a researcher. Thank you, Professor Carvalho!

I would also like to thank Dr. Kalim Gonzales (Guangdong University of Foreign Studies, China) and Dr. Andrew J. Lotto (Department of Speech, Language and Hearing Sciences at the University of Arizona), both of whom generously provided me with the stimuli for this study. Without their invaluable help, it would be impossible to conduct the study the way I had envisioned.

I am grateful to the Research and Project Grant Administrator of the Graduate and Professional Student Council (GPSC) at the University of Arizona for generously funding the equipment used for the data collection in this study, including a Fostex Audio Mixer and Stereo Recorder and a microphone. This equipment is now available for the Second Language Acquisition and Teaching (SLAT) program and will benefit other graduate students in their projects.

Throughout my research, there were numerous people who helped me and to whom I am very grateful. On one Saturday night, after struggling with a Praat script, Dan Brenner (University of Arizona) kindly saved me from my troubles! Does he know how important that
gesture was for me? Jessamyn Leigh Schertz (University of Arizona) also played an important part in this study. As a phonetician herself, she helped me with the selection of the English material and gave me a first glimpse into how to measure VOT. Thanks also to Joseph Casillas (University at Arizona) who taught me how to use Fostex, so that I could go to Brazil and collect the data. My special thanks to my fellow colleagues at the University of Wisconsin-Platteville, who understood the importance of this study and supported me during the year I spent there, especially Dr. Teresa Burns, for her generosity and kind words, and April Feiden, who kindly edited this dissertation and offered precious suggestions. I also would like to thank my colleagues at the University at Albany, SUNY, where I currently teach, for their support and motivation; especially Professor Megan Solon, who gave me priceless feedback on this study.

I also would like to thank those who, throughout my academic life, have had an important influence on my research and career. Among them, I would like to cite my previous professors from UNIARAXA (Brazil), Hunter College, Columbia University, and the University of Arizona. My special thanks to Professor Howard Williams (Teachers College, Columbia University), who was the first professor to make me reflect on the perception of sounds when he was surprised to hear me say that the glottal sound was an <r> sound (and I was surprised that he was surprised)! That was my beginning…

Finally, I would like to thank all the participants in this study, those from the U.S.A. and those from Brazil, who kindly took part in this research. I would like to especially thank Mr. John Walker, director of the C.C.A.A. English School, Ms. Valma Ashidani and Ms. Valda Sánchez, directors of Cultura Inglesa, and Dr. Adriene Costa de Oliveira Coimbra, professor at UNIARAXÁ, whose invaluable support was essential for the success of this study. My special thanks to my family who supported me with their stories and jokes, making me laugh and
bringing me back to “earth” when I most needed it. My special thanks also to my husband Jim Osborne, who was (and is) always there for me, and who has always encouraged me to follow my dreams by telling me, “Why not?”
DEDICATION

This dissertation is dedicated to my brother, Denilson Fernandes Pinto, who was much more than a brother to me; he was a friend and a supporter, who left this life too early, leaving behind so much saudades!

Esta tese de doutorado é dedicada ao meu irmão, Denilson Fernandes Pinto, que foi muito mais que um irmão para mim; ele foi um amigo e um aliado, que partiu dessa vida tão cedo, deixando para trás tanta saudades!
<table>
<thead>
<tr>
<th>TABLE OF CONTENTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>LIST OF TABLES</td>
</tr>
<tr>
<td>LIST OF FIGURES</td>
</tr>
<tr>
<td>ABSTRACT</td>
</tr>
<tr>
<td>CHAPTER 1 – OVERVIEW AND MOTIVATION</td>
</tr>
<tr>
<td>1.1 Introduction</td>
</tr>
<tr>
<td>1.2 Overview of the Dissertation</td>
</tr>
<tr>
<td>1.3 Goals of the Study</td>
</tr>
<tr>
<td>1.3.1 Production: Phonetic Category Formation</td>
</tr>
<tr>
<td>1.3.2 Perception: Language-Specific Perceptual Strategies</td>
</tr>
<tr>
<td>1.3.3 Production and Perception: L1 Phonetic Drift</td>
</tr>
<tr>
<td>1.4 Research Questions</td>
</tr>
<tr>
<td>CHAPTER 2 – LITERATURE REVIEW</td>
</tr>
<tr>
<td>2.1 Introduction</td>
</tr>
<tr>
<td>2.2 L2 Learning of VOT Production: Phonetic Category Formation</td>
</tr>
<tr>
<td>2.3 L2 Learning of VOT Perception: Language-Specific Perceptual Strategies</td>
</tr>
<tr>
<td>2.4 L2 Learning of VOT Production and Perception: L1 Phonetic Drift</td>
</tr>
<tr>
<td>2.5 Summary</td>
</tr>
<tr>
<td>CHAPTER 3 – GENERAL METHODS FOR ALL EXPERIMENTS</td>
</tr>
<tr>
<td>3.1 Introduction</td>
</tr>
<tr>
<td>3.2 Participants</td>
</tr>
<tr>
<td>3.2.1 L2 Learners</td>
</tr>
<tr>
<td>3.2.1.1 L2 Learners’ Proficiency Levels</td>
</tr>
<tr>
<td>3.2.1.2 L2 Language Background Questionnaire</td>
</tr>
<tr>
<td>3.2.1.2.1 Age and Gender</td>
</tr>
<tr>
<td>3.2.1.2.2 Age of Acquisition</td>
</tr>
<tr>
<td>3.2.1.2.3 Knowledge of Another Foreign Language, Experience Abroad, and Contact with Native Speakers</td>
</tr>
<tr>
<td>3.2.1.2.4 Length of Learning</td>
</tr>
<tr>
<td>3.2.1.2.5 Self-Perception of L2 Use</td>
</tr>
<tr>
<td>3.2.1.2.6 Self-Perception of English Skills</td>
</tr>
</tbody>
</table>
LIST OF TABLES

Table 3.1. Descriptive Statistics for the English Language Proficiency Test. . . 52

Table 3.2. Background Information (Ms, SDs, Ranges) of the L2 Learners (Brazilian Portuguese Learners of English), According to Their Level of Proficiency. . . 54

Table 4.1. List of English words used as stimuli in the delayed repetition task. . . 68

Table 4.2. List of Portuguese words, followed by the translation in English, used as stimuli in the delayed repetition task. . . . . . . . . . . . . . . . . . . . . . 70

Table 4.3. Mean (first line) and range (second line) of VOT production of initial bilabials and velars by each language group (the control group [monolingual Brazilian Portuguese speakers] and L2 learners [Brazilian Portuguese learners of English]). Values are presented in milliseconds. . . . . . . . . 94

Table 4.4. Mean VOT values (in ms) of Portuguese stops, produced by Brazilian Portuguese learners of English, in initial position, obtained from a number of studies. . . . . . . . . . . . . . . . . . . . . . . 95

Table 4.5. Mean VOT values (in ms) of L2 English stops, produced by Brazilian Portuguese learners of English in initial position from a number of studies. . . 96

Table 4.6. Mean VOT values (in ms) of Brazilian Portuguese stops in initial position produced by monolingual Brazilian Portuguese speakers from a number of studies. . . . . . . . . . . . . . . . . . . . . . . . . . . 97

Table 4.7. Summary of the results of the production data for each research question. 100

Table 5.1. The frequency and percentage of responses within the ambiguous range (-10 ms and +5 ms) in the two-alternative forced-choice identification test by each language group (the control group - monolingual Brazilian Portuguese speakers, and lower- and higher-proficiency groups - Brazilian Portuguese learners of English). . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . . 125

Table 5.2. Summary of the results of the perception data for each research question. 127
LIST OF FIGURES

Figure 3.1. Distribution of scores obtained by L2 learners (Brazilian Portuguese learners of English) on the English language proficiency test (maximum possible score: 40) 52

Figure 4.1. Examples of L2 English VOT measurements for negative VOT. On the left, the English /b/ in the word *back* (VOT duration is -99.17ms); on the right, the English /g/ in the word *gap* (VOT duration is -109.16ms). The portion between the small vertical mark in the first and second tiers was measured as the VOT. 75

Figure 4.2. Examples of L2 English VOT measurements for positive VOT. On the left, the English /p/ in the word *pig* (VOT duration is 24.06ms); on the right, the English /k/ in the word *cat* (VOT duration is 41.70ms). The portion between the small vertical mark in the first and second tiers was measured as the VOT. 76

Figure 4.3. Examples of Portuguese VOT measurements for negative VOT produced by monolingual speakers. On the left, the Portuguese /b/ in the word *bala* “candy” (VOT duration is -102.81ms); on the right, the Portuguese /g/ in the word *galo* “rooster” (VOT duration is -73.42ms)). The portion between the small vertical mark in the first and second tiers was measured as the VOT. 77

Figure 4.4. Examples of Portuguese VOT measurements for positive VOT produced by monolingual speakers. On the left, the Portuguese /p/ in the word *pato* “duck” (VOT duration is 13.62ms); on the right, the Portuguese /k/ in the word *quinto* “fifth” (VOT duration is 60.47ms). The portion between the small vertical mark in the first and second tiers was measured as the VOT. The portion between the small vertical mark in the first and second tiers was measured as the VOT. 78

Figure 4.5. Overall results of L2 English VOT production of bilabials. L2 learners (Brazilian Portuguese learners of English), mean VOT production of L2 English bilabials by voicing (voiceless, voiced), and proficiency group (lower, higher). 81

Figure 4.6. Overall results of L2 English VOT production of velars. L2 learners (Brazilian Portuguese learners of English), mean VOT production of L2 English velars by voicing (voiceless, voiced), and proficiency group (lower, higher). 82
Figure 4.7. Overall results of Portuguese VOT production of bilabials. L2 learners (Brazilian Portuguese learners of English), and the control group (monolingual Brazilian Portuguese speakers), mean VOT production for Portuguese bilabials by voicing (voiceless, voiced), and language group (control group, L2 learners).

Figure 4.8. Overall results of Portuguese VOT production of velars. L2 learners (Brazilian Portuguese learners of English), and the control group (monolingual Brazilian Portuguese speakers), mean VOT production for Portuguese velars by voicing (voiceless, voiced), and language group (control group, L2 learners).

Figure 4.9. Overall results of L2 learners’ production of L2 English and Portuguese VOT bilabials. L2 learners (Brazilian Portuguese learners of English), mean VOT production for bilabials by voicing (voiceless, voiced), and language mode (Portuguese, English).

Figure 4.10. Overall results of L2 learners’ production of L2 English and Portuguese VOT velars. L2 learners (Brazilian Portuguese learners of English), mean VOT production for velars by voicing (voiceless, voiced), and language mode (Portuguese, English).

Figure 5.1. Distribution of the results of PAFRI identification across all conditions. L2 learners (lower, higher) and the control group (monolingual Brazilian Portuguese speakers), mean proportion of PAFRI identification by language group (control group, lower, higher), and by language mode (Portuguese, English).

Figure 5.2. Overall distribution of the perception data across all conditions. PAFRI identification in the Portuguese and English modes. Lower and higher-proficiency groups of L2 learners (Brazilian Portuguese learners of English), and the control group (monolingual Brazilian Portuguese speakers), mean proportion of PAFRI identification by language group (control group, lower, higher) and by language mode (Portuguese, English) as a function of voice onset time. Error bars show standard errors of the mean.

Figure 5.3. PAFRI identification by lower- and higher-proficiency groups in the English mode. L2 learners (Brazilian Portuguese learners of English), and mean proportion of PAFRI identifications by proficiency group (lower, higher) as a function of voice onset time. Error bars show standard errors of the mean.
Figure 5.4. Results of PAFRI identification in the English mode within the ambiguous area (-10 ms to +5 ms). Lower- and higher-proficiency groups (Brazilian Portuguese learners of English), proportion of PAFRI identification as a function of proficiency level (L, H).  

Figure 5.5. Overall results of PAFRI identification in the Portuguese mode. Lower- and higher-proficiency groups (Brazilian Portuguese learners of English) and the control group (monolingual Brazilian Portuguese speakers), mean proportion of PAFRI identification by language group (control group, L, H).  

Figure 5.6. PAFRI identification in the Portuguese mode. L2 learners (Brazilian Portuguese learners of English), and the control group (monolingual Brazilian Portuguese speakers), mean proportion of PAFRI identifications by language group (control group, L2 learners) as a function of voice onset time. Error bars show standard errors of the mean.  

Figure 5.7. Overall results of PAFRI identification by L2 learners (lower, higher) in English and Portuguese modes. Lower- and higher-proficiency groups (Brazilian Portuguese learners of English), proportion of PAFRI identification as a function of language mode (Portuguese, English).
ABSTRACT

This study investigated the perception and production of L2 English and L1 Portuguese stops in initial position by analyzing the acquisition of voice onset time (VOT) categories. 36 Brazilian Portuguese (BP) learners of English and 36 monolingual BP speakers, all of them living in Brazil, participated in this study. There were two language sessions, English and Portuguese (monolinguals took part in the Portuguese session only). In each language session, participants took part in a production and a perception task in the respective language (the tasks were mirror-images of each other). To elicit the production data, participants took part in a delayed repetition task. To elicit the perception data, participants took part in a two-alternative forced-choice identification test. The analysis of the data showed that improvement in L2 may entail improvement in L2 perception of stops. On the other hand, the lack of effects of proficiency in L2 production of stops may suggest occurrence of learning stabilization of L2 VOT categories. L1 phonetic drift was observed in the production of the Portuguese /b/, /k/, and /g/ (but not for /p/). However, no effects of L2 learning on L1 was observed for the perception of Portuguese /b/-/p/. L2 learners who had learned English in their L1 country and in formal settings demonstrated that they were able to form new phonetic categories for the production of /p/, /b/, and /g/. The higher-proficiency group (but not the lower-proficiency group) demonstrated that they developed language-specific phonetic strategies for /p/-/b/ since they were able to process the same set of sounds on a continuum from /b/ to /p/ as either L1 or L2 stops as a function of language mode. The perception study showed that language-specific phonetic strategies, which had been observed among highly fluent bilinguals, could also be possible for this population.
CHAPTER 1 - OVERVIEW AND MOTIVATION

1.1 Introduction

“I am from São Baulo.” This statement shows how a professor in an American university told me he understood what his Brazilian students were saying to him. He added that he could not understand what they were saying, since he knew about “São Paulo” but not “São Baulo.” Second language pronunciation can be challenging, especially for adults, who are not always sensitive to relevant but fine-grained differences between their first language and the target language. English /b/ and Portuguese /p/, for instance, are phonetically similar (both pronounced as voiceless), but phonemically different. On the other hand, English /p/ and Portuguese /p/ are phonemically similar, but phonetically different, (e.g., English /p/ is aspirated whereas Portuguese /p/ is unaspirated.) As a result, Brazilian Portuguese speakers who are learning English tend to pronounce English /p/ with the same values as the Portuguese /p/, generating a potential source for miscommunication.

The present study concerns the acquisition of English /p b k g/ as revealed by one acoustic correlate voice onset time (VOT) produced by adult second language learners of English whose first language is Brazilian Portuguese (BP). The stops /t d/ were not included in this study because palatalization is expected to occur in Portuguese when dental stops /t d/ precede front vowels [i ɪ]. In this case, /t d/ are palatalized and alveo-palatal affricative voicesless [ʃ] and voiced [ʤ] sounds are produced (e.g., Cristófaro Silva, Barboza, Guimarães, & Nascimento, 2012). Since palatalization could interfere in the results of this study, /t d/ were not included in this research. The L2 learners participating in this study have been exposed to English only in a

---

1 The correct name of the city in Brazil is São Paulo (not São Baulo).
formal, classroom context. More specifically, this study investigates the formation of L2 phonetic categories by considering the interaction between learners’ first language (L1) and L2 phonetic systems.

VOT is defined as the temporal distance (measure in milliseconds) between the release of the stop closure and the onset of glottal vibration of the following vowel (Lisker & Abramson, 1964). VOT values of stop consonants give acoustic information and perceptual cues for voiced and voiceless, aspirated and unaspirated stop categories (e.g., Abramson & Lisker, 1970; Lisker & Abramson, 1967). The release of the stop is shown on a spectrogram as a burst or a “brief interval of high-intensity noise” (Lisker & Abramson, 1967, p. 2), and the onset of voicing can be identified by the onset of periodicity in the acoustic waveform (see Francis, Ciocca & Yu [2002] for a study considering a number of other methods of measurement of voicing onset). VOT can have negative and positive values. By convention, the value zero is assigned to the instant of burst onset (Lisker & Abramson, 1967). VOT is negative if voicing starts before the release of the stop, called voicing lead or prevoicing; VOT is positive if it occurs after the release of the stop, called voicing lag. In this case, VOT can have a short-lag, in which phonation begins at or close to the stop release, and voiceless unaspirated stops are produced. VOT can also have a long-lag, in which a considerable delay between the stop release and the onset of the vibration of the vocal folds occurs, and voiceless aspirated stops are produced.

Lisker and Abramson (1964) provided three possible VOT categories or central tendencies: prevoicing (negative values), unaspirated stops (means ranging from 4 to 29 ms), and aspirated stops (means ranging from 58 to 80 ms). Cho and Ladefoged (1999) presented four phonetic categories of possible VOT values: unaspirated stops (around 30 ms), slightly aspirated stops (around 50 ms), aspirated stops (around 90 ms), and highly aspirated stops (for languages
such as Tlingit and Navajo). This is a continuous measure that allows us to investigate speech categorizations with a sensitive tool.

Whereas Portuguese and English contrast stops with the same phonological category (voiced and voiceless), speakers use different phonetic categories to differentiate them. Whereas in initial position, Portuguese /b d g/ are realized as prevoiced sounds, in English they are most commonly realized with short-lag VOT values, although they can also be realized with voicing lead (less common), but phonetically voiceless in initial position. Therefore, English /b d g/ are phonemically voiced stops, but phonetically voiceless, since they have no prevoicing or no negative VOT values. Regarding the Portuguese stops /p t k/, they are realized with short-lag, and they are perceived as unaspirated. In English, these stops are realized with long-lag VOT values, and they are perceived as aspirated.

Although traditionally the VOT of Brazilian Portuguese (BP) stops is described as having two possible categories, voicing lead and short lag, Alves (2011) showed some evidence of the occurrence of aspirated stops (long-lag VOT), at least for /k/. The author suggests that BP aspirated stops could be a phonetic variation (allophone) of voiceless stops. In a more recent study (Alves, 2015), BP speakers produced Portuguese /k/ slightly aspirated (VOT between 35-55 ms) 67% of the time, and aspirated (VOT between 55-95 ms) 33% of the time.

In a more recent study involving the production of stops by adult BP speakers (Melo, Mota, Mezzomo, Brasil, Lovatto, & Arzeno, 2014), the acoustic characteristics of BP stops were reported. Melo et al. observed that voiced stops displayed long negative values (from zero) while voiceless stops had short-lag values (closer to zero). The burst amplitude was only slightly superior for initial voiceless stops, but not significantly different in medial position. Finally, they reported that the closure in medial stop was larger for voiceless than for voiced stops. Studies
such as that of Melo et al. are important for the understanding of the acoustic characteristics of the BP stops, since there are still few studies in this area (Alves & Magro, 2011).

Studies of the acquisition of L2 English VOT categories by BP speakers are rather scarce. Alves (2011) analyzed the production of L2 English VOT categories by Brazilian Portuguese learners of English in semispontaneous speech (e.g., interviews). In her work, she found that the production of L2 English /p/ and /t/ by BP learners of English had significantly shorter VOT values than the same consonant stops produced by native American English speakers. No significant difference between the velar stops produced by L2 learners and native American English speakers was found. Although the results obtained by Alves cannot be generalized (e.g., the sample size was limited to 3 advanced L2 learners), her work provides good insight on how BP learners of English produce L2 stops and the effects of place of articulation in the VOT category formation.

The acquisition of English voiced and voiceless sounds, as revealed by VOT, has been shown to be a source of difficulties for learners of English with a diverse language background such as Italian, French, Dutch and Spanish (e.g., Flege & Eefting, 1987a, 1987b; García-Sierra, Diehl & Champlin, 2009; MacKay, Flege, Piske, & Schirru, 2001) as well as Portuguese (e.g., Alves, 2011; Alves & Magro, 2011; Cohen, 2004; França, 2011; Paterson, 2011; Reis & Nobre-Oliveira, 2007; Rocca, 2003). The perception and production of L2 stops are intimately related to how L1 and L2 phonetic systems interact. L2 learners have to manage two phonetic systems, which inevitably influence one another. These two phonetic systems “cannot remain hermetically sealed from one another in all respects” (Mack, 2003, p. 340). How these two systems interact and the extent to which they influence one another are not yet well understood. Some factors, however, seem to influence the interaction of L1-L2 phonetic systems, such as L2 usage, age of
acquisition, language context, physical location, and affective factors, among other factors (e.g., Baker & Trofimovich, 2003). In addition, the likelihood that a new L2 category will be established depends on the L2 learners’ perceived distance between the L2 sound and the closest L1 sound (e.g., Flege, 1995; Flege, Schirru, & MacKay, 2003).

A number of studies have provided evidence for interaction between the L1-L2 phonetic systems (e.g., Caramazza et al., 1973; Flege, 1987; Flege, 2002; Flege & Eefting, 1987b; Flege, Schirru & Mackay, 2003; Fowler, Sramko, Ostry, Rowland, & Hallé, 2008; MacKay, Flege, Piske, & Schirru, 2001; Sancier & Fowler, 1997; Sundara, Polka, & Baum, 2006). For instance, Fowler et al. (2008) showed that French-English bilingual in Canada produced distinctive stops in French and English. For instance, they produced longer VOTs in their English stops and shorter VOTs in their French stops. However, when compared to monolingual speakers, their stops were revealed to have significantly shorter English VOTs and longer French VOTs, with intermediate values between those of native English and French speakers. In another study (Sancier & Fowler, 1996), a Brazilian-English bilingual shifted her production of stops toward the characteristics of the ambient language. For instance, after spending a month in Brazil, her stop production in both languages had shorter VOT values than after spending a month in the United States, showing a clear bidirectional cross-language influence.

The present study investigates the acquisition of L2 English stops through perception and production experiments in both English and Portuguese contexts. The general goal of this study is to contribute to the understanding of the interaction between L1-L2 phonetic systems of late L2 learners who have learned English in a formal context, with limited exposure to L2 input (e.g., nearly no access to English native speakers).
1.2 Overview of the Dissertation

Following this brief introduction, Chapter 2 presents the literature review of the main studies and contributions in the perception and production of L2 VOT, which have guided the present study. Emphasis is given to the L2 category formation of L2 VOT, language-specific perceptual strategies, and L1 phonetic drift. Chapter 3 describes the participants, the settings, and general procedures of the four experiments conducted in this study. Chapter 4 presents the experiments that elicited the production data, a delayed repetition task, conducted in English and in Portuguese, followed by the data analyses and results. Chapter 5 presents the experiments that elicited the perception data, a two-alternative forced-choice identification test, conducted in English and Portuguese, followed by the data analyses and results. Chapter 6 discusses the results of the study, considering the main research and teaching implications as well as avenues for future research. Chapter 7 presents the main conclusions of the study.

1.3 Goals of the Study

There are three main goals in this study: The investigation of phonetic category formation in L2 production of stops; the investigation of language-specific perceptual strategies in L2 perception of stops; and the investigation of L1 phonetic drift in L1 Portuguese.

1.3.1 Production: Phonetic Category Formation

This study analyzes the production of English and Portuguese /p b k g/ in word initial position, as revealed by VOT, in the speech of BP learners of English living in Brazil. The dental stops /t d/ were not included in this study because /t d/ are palatalized before front vowel [i, ɪ] in Brazilian Portuguese, and alveo-palatal affricative voicesless [ʃ] and voiced [dʒ] sounds are then
produced (e.g., Cristófaro Silva, Barboza, Guimarães, & Nascimento, 2012). Since the goal of this study is to investigate the production and perception of stops, the dental stops were not included in the research. Language context for each language session was controlled in order to help L2 learners process the sounds in the respective language mode (e.g., Grosjean, 2001). Comparisons of L2 production across lower- and higher-proficiency groups were conducted. These comparisons aimed to see whether L2 learners showed learning progress toward the target phonemes across proficiency levels (e.g., whether general improvement in L2 language entails improvement in production of VOT categories). In addition, comparisons between the production of L2 English and L1 Portuguese stops by L2 learners were conducted. These comparisons aimed to see whether there were any differences between the productions of the stops produced by the lower- and higher-proficiency groups and, if so, whether these differences were due to the formation of new categories.

1.3.2 Perception: Language-Specific Perceptual Strategies

The second goal of this study is to investigate the formation of language-specific perceptual strategies by L2 adult learners. This part of the study compared L2 learners’ perception of word-initial /p b/ in a VOT continuum in English and Portuguese contexts between lower- and higher-proficiency learners. This part of the study is built on a previous study (Gonzales & Lotto, 2013) conducted with highly fluent bilinguals. It aims to address whether L2 learners were able to demonstrate language-specific perceptual strategies (e.g., whether they were able to process the same set of sounds as English and as Portuguese sounds, according to the respective language context). Although language-specific perceptual strategies have been found in early, fluent bilinguals (e.g., García-Sierra, Diehl, & Champlin, 2009; Gonzales &
Lotto, 2013), it is not clear whether late L2 learners are also able to develop the same skills. This study, therefore, provides important contributions to the understanding of L2 phonemic representations of sounds and the interaction between L1-L2 phonetic systems.

1.3.3 Production and Perception: L1 Phonetic Drift

A third goal of this study is to investigate whether L1 Portuguese perception and production of consonant stops are influenced by L2 knowledge. The perception and production of Portuguese stops in initial position produced by monolingual Brazilian Portuguese speakers were analyzed, and then compared with the perception and production of Portuguese produced by L2 learners of English whose L1 was Portuguese. This analysis revealed whether knowledge of VOT categories in L1 and L2 had asymmetrical influences in the L1-L2 interaction (e.g., only L1 influences L2), or whether it is bidirectional (L1 and L2 influence each other). This part of the study also revealed whether such influences varied across L2 proficiency groups. Ultimately, the investigation of L1 phonetic drift in the perception and production of VOT categories of BP learners of English aimed to contribute to the understanding of the dynamic and complex processes in which L1 and L2 self-organize their systems. Throughout this study, the term L1 phonetic drift is used to refer to the effects of the acquisition of an L2 on an L1. The potential effects of the acquisition of an L2 on an L1 were measured by comparing the Portuguese production and perception habits of monolingual Portuguese speakers with that of native Portuguese speakers who were learning English as an L2.
1.4 Research Questions

The research questions for the production and perception studies on the acquisition of L2 VOT values are listed below. In order to elicit the production data, L2 learners and monolingual BP speakers (the control group) participated in a delayed repetition task in English (only L2 learners) and in Portuguese (both groups). For the production part, the research questions are:

**RQ1. Does proficiency affect the production of L2 English stops?**

A number of studies have provided evidence of transfer of L1 VOT values to the production of stops in L2, especially at lower levels of L2 proficiency (e.g., Flege, 1987; Flege & Hillenbrand, 1987). Higher-proficiency learners, however, have shown the ability to approximate their L2 production to the production of native speaker norms with respect to VOT norms (e.g., Caramazza et al., 1973; Flege 1987, 1991). One question is whether L2 learners who had acquired their L2 in the classroom in their L1 country with limited exposure to L2 input will demonstrate differences in the production of L2 stops across levels of proficiency.

**Hypothesis:** It is hypothesized that higher-proficiency L2 learners will demonstrate the production of L2 VOT values more similar to what is expected from native English speakers than lower-proficiency learners. For instance, it is expected that higher-proficiency learners will show more instances of devoicing for English /b/ and a longer period of aspiration for English /p/ than lower-proficiency learners. If this hypothesis is correct, this study will demonstrate improvement in production of VOT categories, showing that L2 VOT categories may be acquired, even in conditions of formal foreign language instruction and with limited exposure to L2.
**RQ2.** Is L1 Portuguese production of stops affected by L2 learning?

Previous studies have shown that L1 is not a static phonetic system. L1 phonetic drift (i.e., the effects of the acquisition of an L2 on the L1) has been observed among late L2 learners as well as among novice L2 learners (e.g., Chang, 2011; Flege, 1987; Lev-Ari & Peperkamp, 2013). Nevertheless, there are some studies that show that L2 learners have failed to demonstrate influences of L2 on their L1 in terms of VOT categories (e.g., Flege, 1991). Our question is whether L1 phonetic drift would be found in the L1 Portuguese production of stops by BP learners of English who had learned English in classroom settings in their L1 community.

**Hypothesis:** It is hypothesized that the production of L1 Portuguese by BP learners of English will be different from the monolinguals, displaying L1 phonetic drift. The L1-L2 influences are expected to be bidirectional. There are two possibilities: Either L1 phonetic drift will occur only with the higher-proficiency group, or it will occur with all L2 learners. Since previous studies have shown mixed results, the outcome is uncertain.

**RQ3.** Do L2 learners maintain separate distributions for the production of L2 English and L1 Portuguese stops?

Previous studies have shown the probability that a new L2 category will be established is related to the L2 learners’ perceived distance between the new L2 sound and the closest L1 sound. As a result, phonetic category assimilation or phonetic category dissimilation may take place. In phonetic category assimilation, merged L1-L2 VOT values for the new L2 category may occur. In phonetic category dissimilation, L2 and/or L1 may deviate from monolingual norms (e.g., Flege, 1995), even though new phonetic categories are formed. One question is whether Portuguese-speaking learners of English would be able to maintain separate
languages. Distributions of stops in their L1 Portuguese and their L2 English, even though they had learned English in a formal context with limited L2 input.

**Hypothesis:** It is hypothesized that highly proficient learners (but not lower-proficiency learners) will be able to maintain separate distributions for the production of L2 English and L1 Portuguese stops. It is not clear, however, whether the higher-proficiency group will demonstrate a separate category for all L2 consonant stops investigated in this study, or whether some L2 stops will turn out to be more difficult to acquire than others. For instance, L2 learners might find it more difficult to produce L2 sounds within short-lag VOT value range, since this is an ambiguous area for them (e.g., L2 learners might avoid devoicing English /b/).

In order to elicit perception data in this study, L2 learners and monolingual BP speakers participated in a two-alternative forced-choice identification test in English (only L2 learners) and in Portuguese (both groups). L2 learners were exposed to the same stimuli (a VOT continuum from /b/ to /p/) in two separate language sessions. In the English context, L2 learners were asked to identify perceptual boundary between phonemically voiced and voiceless English stops as they were induced to think they were listening to English sounds. In the Portuguese context, hearing the same stimuli, participants were asked to identify perceptual boundary between phonemically voiced and voiceless Portuguese stops as they were induced to think they were hearing Portuguese sounds. For the perception part of this study, the research questions are as follows:
RQ4. Does proficiency affect the perception of L2 English stops?

The Speech Learning Model (SLM) states that L2 learners will establish a new phonetic category in L2 for those new sounds that are perceived to be dissimilar from the closest L1 sounds. On the other hand, a new category will be less likely to be established when sounds in L1 and L2 are perceived to be similar. It is expected that L2 learners will not strive to learn sounds in L2 and L1 that are perceived to be the same because L2 learners will perceive them as belonging to their L1 inventory. However, those L2 sounds perceived to be different from L1 will require learning and L2 learners will strive to learn the new L2 sounds. The model also predicts that, as we grow older, it becomes more difficult to establish a new category since L1 phonetic categories become stronger attractors of L2 sounds (e.g., Flege, 1987; Flege, 1995; Flege & Eefting, 1987b; Flege, et al., 2003). One question is whether L2 learners who acquire their L2 in the classroom in their L1 country with limited exposure to L2 input will demonstrate differences in the perception of L2 stops across levels of proficiency. For instance, would proficiency level matter for late learners who may not have established new L2 categories?

Hypothesis: It is hypothesized that proficiency will affect L2 learners’ perception of VOT. For instance, higher-proficiency learners are expected to identify more instances of English /b/ within short-lag values than lower-proficiency learners, showing activation of their monolingual English mode. Along the language-activation continuum, the lower-proficiency group is expected to posit itself more toward a unilingual than bilingual position. For instance, lower-proficiency group is expected to identify more instances of /p/ within short-lag values.
RQ5. Is L1 Portuguese perception of stops affected by L2 learning?

As explained in RQ2, L1 VOT values are not immutable; rather, they tend to fluctuate depending on the language context (e.g., Major, 1992; Sancier & Fowler, 1996). L1 phonetic drift has been observed to occur among late L2 learners as well as among learners who have just had brief experiences with their L2 (e.g., Chang, 2011; Flege, 1987; Lev-Ari & Peperkamp, 2013).

**Hypothesis:** It is hypothesized that the perception of Portuguese by L2 learners will be affected by L2 learning. It is not clear, however, whether lower- and higher-proficiency groups will differ from each other. For instance, it might be possible that the higher-proficiency group identifies fewer instances of Portuguese /p/ within short-lag VOT values than the lower-proficiency group, even though results from the lower-proficiency group and the monolingual group might not overlap.

RQ6. Do L2 learners demonstrate developed language-specific perceptual strategies for VOT categories when processing sounds in their L1 or in their L2?

Previous studies have indicated that only fluent bilinguals are able to demonstrate developed language-specific perceptual strategies when exposed to the same stop sounds in L1 and L2 (e.g., García-Sierra et al., 2009; Gonzales & Lotto, 2013). For instance, they shift their perceptual boundary when exposed to a VOT continuum from /b/ to /p/ as a function of language mode (e.g., Gonzales & Lotto, 2013). The assumption is that highly proficient learners are more likely to demonstrate language-specific perceptual strategies than lower-proficiency learners (e.g., García-Sierra et al., 2009).
**Hypothesis:** It is hypothesized that, for higher-proficiency L2 learners (more than for lower-proficiency learners), the perceptual boundary between English /p/ and /b/ sounds will be more similar to that expected from native English speakers. It is hypothesized that only higher-proficiency learners will demonstrate developed language-specific perceptual strategies for English VOT categories. For instance, their perceptual boundary between phonologically voiced and voiceless stops within short-lag VOT values in the English context and in the Portuguese context will differ. Lower proficiency learners are not expected to show any significant shift in perception across language contexts; rather, their results are expected to overlap the ones produced by monolingual Portuguese speakers.
CHAPTER 2 - LITERATURE REVIEW

2.1 Introduction

This chapter reviews a number of significant studies in the acquisition of perception and production of new voice onset time (VOT) categories in second languages. It focuses specifically on whether L2 learners may (or may not) display phonetic categorization for L1 and L2 production of consonant stops, and whether learning experience affects the acquisition of L2 VOT categories. It also focuses on whether L2 learners demonstrate that they possess language-specific perceptual strategies when perceiving consonant stops in L1 and L2, and whether the learning of L2 stops could lead to a unidirectional or bidirectional L1-L2 interaction.

2.2 L2 Learning of VOT Production: Phonetic Category Formation

A substantial number of studies have investigated the production of VOT by early and late bilinguals in order to determine whether L2 learners are able to create separate phonetic categories for the production of L2 sounds (e.g., Bullock, Toribio, González, & Dalola, 2006; Caramazza, Yeni-Komshian, Zurif, & Carbone, 1973; Flege & Eefting, 1987a, 1987b; MacKay, Flege, Piske, & Schirru, 2001; Major, 1987; Nathan, Anderson, & Budsayamongkon, 1987; Sancier & Fowler, 1996; Zampini, 1998). It has been argued that the likelihood of establishing a new L2 category depends on the perceived distance between the L2 sound and the closest L1 sound (e.g., Flege, 1995; Flege, Schirru, & MacKay, 2003). This assumption is described by the Speech Learning Model (SLM), an L2 model conceptualized by Flege and his colleagues (Flege, 1995). The SLM states that if an L2 sound is perceived to be sufficiently similar to the closest L1 sound, a merged phonetic category between L1 and L2 may emerge. In this case, phonetic
category assimilation would have occurred (e.g., Caramazza et al., 1973; Flege, 1987; Flege & Eefting, 1987b). Category assimilation occurs as the result of equivalence classification, where “a single phonetic category will be used to process perceptually linked L1 and L2 sounds (diaphones)” (Flege, 1995, p. 239). Category formation for L2 sounds will be blocked since the sounds are identified as instances of an L1 category.

The SLM also hypothesizes that the likelihood of establishing a new L2 category increases as the perceived dissimilarity between the new L2 sound and the closest L1 sound increases. According to Flege et al. (2003, p. 470), “bilinguals strive to maintain phonetic contrast between all of the elements in their L1/L2 phonetic space, just as monolinguals strive to maintain phonetic contrast among the elements making up their L1 phonetic space.” The formation of a new category in L2 may result in the production of L2 sounds and/or the deviation of L1 sounds from monolingual norms. Therefore, the SLM predicts that L2 learners will be able to establish new phonetic categories for L2 sounds that are perceived to be sufficiently dissimilar from L1 sounds.

The SLM also predicts that “early bilinguals will be more likely to establish new phonetic categories for L2 sounds than late bilinguals will be” (Flege et al., 2003, p. 469) because age is expected to have an effect on how the L1-L2 interact. More specifically, it is expected that, as we grow from childhood to adulthood, the phonetic categories in the L1 become stronger attractors of L2 sounds, whereas, for early bilinguals (children), L1 categories are not yet fully developed (e.g., Hazan & Barrett, 1999; Parnell & Amerman, 1978; Walley & Flege, 2000). It is important to point out that, according to the SLM, adults are also able to successfully acquire L2 sounds, as long as the right conditions are met, such as the quality of input and the time invested.
A number of studies have given support to the SLM (e.g., Caramazza et al., 1973; Flege, 1987; Flege & Eefting, 1987b; Flege et al., 2003; Munro, 1993). In Flege’s (1987) study, for instance, phonetic category assimilation was observed in the production of L2 /t/ by English and French adults. The study showed that even highly proficient L2 learners did not produce a native-like French /t/, in terms of VOT values: Although the most experienced English speakers of French, who were living in Paris, produced French /t/ that approximated the French phonetic norms, it was still significantly different from monolingual French speakers. On the other hand, native French speakers of English who were living in Chicago produced significantly shorter English VOT values than monolingual English speakers. Their French /t/ had VOT values that were intermediate between those VOT values of French and English monolinguals. The fact that experienced L2 learners may approximate, but not achieve, the phonetic norms of L2 stops is explained by the underlying assumption that L2 learners perceived French /t/ and English /t/ phonetically equivalent. For Flege, equivalence classification shapes L2 production, preventing learners from forming new phonetic categories of similar sounds.

There is some evidence that early L2 learners are more likely to establish new phonetic categories in the L2 than adults, and that adult L2 learners are more likely to produce intermediate VOT values than early L2 learners (all else being equal) (e.g., Caramazza et al., 1973; Flege, 1991; Kang & Guion, 2006). In Caramazza et al.’s (1973) study, for instance, French-English bilinguals, who acquired English by age 7 in Canada, were asked to read a set of English and French stop-initial words in two separate language sessions. While bilinguals produced French stops in a native-like fashion, the English stops were significantly different from those of the monolinguals. For instance, their English /t/ (48ms) had an intermediate VOT value. Flege (1991) found similar results with Spanish-English bilinguals. Participants were
asked to read words in carrier phrases and in isolation switching between Spanish and English.

Native Spanish speakers who learned English early in life, at ages 5-6, produced VOT values for English /t/ that did not differ from monolingual English speakers. However, late learners of English, who had learned English as adults, produced English /t/ with “compromised” VOT values, that is, VOT that had intermediate values between short-lag (Spanish) and long-lag (English) values. Kang and Guion (2006) also found similar results. In their study, early Korean-English bilingual adults were able to produce VOT values similar to those of native speakers of Korean and English; however, late bilinguals produced VOT values that differed from those of native speakers of both languages.

Some studies, on the other hand, contradict these findings, showing that early bilinguals might not produce VOT values in a native-like fashion (e.g., Flege & Eefting, 1987a; Fowler, Sramko, Ostry, Rowland, & Halle, 2008). Flege and Eefting (1987a), for instance, showed that Spanish-speaking learners of English, both adults and children, who learned English as an L2 by the age of 5 or 6, produced English stops differently from English monolinguals (age-matched groups): Their L2 VOT values for voiceless stops were shorter than the ones produced by monolinguals. Flege and Eefting concluded that early L2 learners might not be able to acquire L2 phonetic categories for voiceless stops. On the other hand, this study gives support to the view that “both the L1 and L2 phonetic systems remain activated to some degree” (Flege, 1991, p. 396).

Nevertheless, the formation of a phonetic category in L2, which can result in phonetic category dissimilation, has been investigated in a number of studies (e.g., Flege & Eefting, 1987b; Hazan & Barrett, 1999; Parnell & Amerman, 1978; Walley & Flege, 2000). Flege and Eefting (1987b) showed that Dutch speakers of English produced Dutch /t/ and English /t/
differently. All subjects produced /t/ with longer VOT values in English than in Dutch. However, the greater difference between English and Dutch /t/ was observed in the more proficient group. For instance, the proficient Dutch speakers (those who sounded less foreign accented – most of them English majors) produced Dutch /t/ with shorter positive VOT than that of non-proficient Dutch speakers (those who sounded more foreign accented – most of them Engineering majors), which indicates the influence of L2 in their native language. The authors interpret this result as evidence that the proficient group was able to establish a new phonetic category of the English /t/, even though their production differed from that of monolinguals.

Some L2 stops might be more difficult to acquire than others. Zampini (1998) investigated the learning of L2 Spanish VOT values among native English speakers who were enrolled in a Spanish phonetics course. The students participated in three sessions in a semester. The production portion of the study consisted of repetition of English and Spanish sentences. L2 learners were relatively successful in producing Spanish /p/, with VOT values that were significantly shorter than their VOT values for English /p/. However, they were unsuccessful in producing prevoiced Spanish /b/. Zampini suggests that the prevoicing feature might take longer to learn than the short VOTs for these L2 learners since the short-lag category already exists in English, whereas prevoicing is a new category. This longitudinal study suggests that different stops may present different levels of difficulties for L2 learners.

Interestingly, the production of VOT seems to be rather fluid and not fixed (Sancier & Fowler, 1996). Sancier and Fowler (1996) investigated the speech production of stops by a bilingual Brazilian Portuguese-English speaker over time (before and after her trips to Brazil and the U.S.). They found that the speaker shifted her VOT production of stops as a function of ambient language due to recency. For instance, the speaker’s English VOTs were significantly
longer after her experience in the U.S. than after her experience in Brazil. The speaker’s production of VOT values fluctuated depending on the participant’s recent ambient language exposure, displaying what the authors called temporary “gestural drift” in English and Portuguese toward the most recent language experience.

Although L2 research has contributed greatly to the understanding of the acquisition of L2 stops, questions related to developmental patterns of L2 VOT categories, especially related to late L2 learners who have learned the target language in their L1 country with limited exposure to L2 input, have been largely unanswered. Some of these questions are, for instance, whether general improvement in L2 would entail improvement in the production of the stops in L2, and whether the formation of new production categories in L2 would entail improvement in the production of L2 stops. The present study aims to address these and other related questions through the analyses of the production of English and Portuguese initial stops by L2 BP learners of English and monolingual BP speakers.

The next section examines relevant studies on the perception of L2 VOT categories. More specifically, the section reviews a number of studies on phonetic boundary shifts and language-specific perceptual strategies, and addresses how the present study may contribute to these areas of inquiry.

2.3  L2 Learning of VOT Perception: Language-Specific Perceptual Strategies

Unlike monolingual speakers, L2 learners cope with two phonetic systems. Crucial questions may arise concerning how these two systems interact; for instance, the extent to which each phonetic system affects each other. Studies on the perception of VOT boundaries by L2 learners have helped understanding the intrinsic ways in which these two phonetic systems may
interplay (e.g. Bohn & Flege, 1993; García-Sierra, Diehl, & Champlin, 2009; García-Sierra, Ramírez-Esparza, Silva-Pereyra, Siard, & Champlin, 2012; Gonzales & Lotto, 2013; López, 2012; Williams, 1977). These studies have aimed to address whether bilinguals could develop phonemic categories for sounds that are phonetically similar in L1 and L2 (e.g., sounds that share acoustic information in L1 and L2), but are phonemically different in both languages. The investigation of the perception of L2 VOT values can provide insights on how L1-L2 phonetic systems interact.

In order to investigate whether L2 learners display language-specific perceptual strategies, researchers expose L2 learners to the same stimuli in two separate language contexts, L2 and L1 modes. Participants are asked to categorize the same speech stimuli on a continuum (e.g., from /b/ to /p/) in L1 and L2 contexts, and determine whether L2 learners shift their phonetic boundary as a function of language mode only. If L2 learners shift their phonetic perception as a function of language context, it is reasonable to assume that L2 learners have demonstrated that they possess language-specific perceptual strategies for L1 and L2. Creating the appropriate language context, however, is important in order to prompt the desirable language mode (Grosjean, 1985, 1994, 1997, 1998, 2001, 2013); otherwise, the results of the experiment may be compromised (e.g., ambiguous findings), since a high level of activation in L2 might not have been reached.

The first studies on the phonetic boundaries of L2 learners across language modes demonstrated conflicting results (Bohn & Flege, 1993; Caramazza et al., 1973; Elman et al., 1977; Flege & Eefting, 1987a, 1987b; Hazan & Boulakia, 1993; Williams, 1977). For instance, in Caramazza et al.’s (1973) study, English-French bilinguals were not able to demonstrate a phonemic boundary across language contexts. Their perception of L2 English and L1 French
yielded similar results: The VOT values for the phonetic boundary had intermediate values (between English and French). Although bilinguals differed from monolinguals, they did not shift their phonetic boundary across language contexts. Another study (Williams, 1977) involving Spanish-English bilinguals showed similar results. In Williams’ (1977) study, bilinguals were asked to label and discriminate a synthesized continuum from /ba/-/pa/ in either English or Spanish modes. Only 3 of 8 Spanish-English bilinguals demonstrated perceptual sensitivity to the VOT continuum in the ambiguous region, whereas the majority of the participants failed to shift boundary across language modes.

In some studies (e.g., Bohn & Flege, 1993; García-Sierra et al., 2009), not only L2 learners, but also monolingual speakers, shifted their perceptual phonetic boundary according to the language mode. In these cases, however, the design of the experiments seemed to have an effect on the results. Bohn and Flege (1993) investigated the effects of language sets for Spanish-English bilinguals and monolinguals. Their results showed that both bilingual and monolingual groups had some language set effects. For instance, monolingual Spanish speakers identified short-lag English /d/ tokens as voiced in 65% of instances. This study showed that the language effect was observed in both bilinguals and monolinguals. Although it is not clear whether bilinguals and monolinguals used similar strategies, Bohn and Flege (1993, p. 284) offered a couple of possible explanations for their results: English monolinguals might have noticed the presence of the Spanish stops in the Spanish questions that were interspersed among the Spanish stimuli. Or, participants might have been familiar with the Spanish accent through the media (e.g., films, TV), which may have given English monolinguals “tacit awareness that English /t/ is produced with shorter VOT values.”
Monolinguals also demonstrated sensitivity to language context in García-Sierra et al.’s (2009) study. Spanish-English bilinguals heard a continuum ranging from /ga/ to /ka/ (27 VOT steps) in two language sessions, English and Spanish. The stimuli were preceded by precursor sentences either in English or Spanish. Both bilinguals and monolinguals shifted their phonemic boundary. The authors suggested that, since Spanish monolinguals (those who had self-described as having low confidence in Spanish) were college students, the changes were that they had “learned the basis of a second language during high school and/or college” (p. 377), and that this knowledge was therefore enough to shift the phonetic boundary.

Despite those studies (Caramazza et al., 1973; Williams, 1977) failure to demonstrate evidence of boundary shifts among bilinguals and a few other studies showing boundary shifts among monolinguals (e.g., Bohn & Flege, 1993; García-Sierra et al., 2009), a much larger number of studies have shown that, in fact, bilinguals (but not monolinguals) are able to shift boundary of VOT values when exposed to different language contexts (e.g., Elman et al., 1977; García-Sierra et al., 2012; Gonzales & Lotto, 2013; Sundara & Polka, 2008). In these studies, language mode has been relevant in order to promote high levels of processing and to prompt bilinguals to demonstrate language-specific perceptual strategies for L1 and L2 (e.g., Elman et al., 1977; Flege & Eefting, 1987b; García-Sierra et al., 2009; Gonzales & Lotto, 2013; Hazan & Boulakia, 1993; López, 2012; Olson, 2013). For instance, in Elman et al. (1977), Spanish-English bilinguals shifted their boundary perception of stops (/b/ and /p/), depending on the language setting. Their level of bilingualism had an effect on the results, showing that only the more proficient bilinguals would overlap with monolinguals. The other participants demonstrated shifts toward the direction of monolinguals, although there were no overlaps.
In Flege and Eefting (1987b), the authors describe the development of new L2 phonetic categories for initial consonant stops, for languages in which L1 and L2 phonetic space overlaps, as the “new wine in old bottles” phenomenon (p. 186). For instance, L2 learners may be able to establish new categories for L2 stops, but these new categories may differ from those of the native speakers. Flege and Eefting investigated the perception of stops on a continuum ranging from /da/ to /ta/ in two separate language sets, Dutch and English, by adult Dutch learners of English. (Voiceless stops are aspirated in English, and unaspirated in Dutch.) Bilinguals showed a double phonemic boundary across language context, even though the boundary shift was smaller in comparison to an expected difference between Dutch and English monolinguals.

There is evidence that early bilinguals display language-specific perceptual strategies due to their high sensitivity to language context, showing that they are able to perceive fine-grained differences in stops between L2 and L1 (e.g., Elman et al., 1977; García-Sierra et al., 2012; Gonzales & Lotto, 2013; Sundara & Polka, 2008). In Gonzales and Lotto (2013), Spanish-English bilinguals and English monolinguals were exposed to a VOT continuum in two language contexts in order to determine whether they would display language-specific perceptual strategies. All bilinguals learned both languages before age 8. The stimuli were created from a natural speech recording of the words bafri and pafri pronounced as English words and as Spanish words. 14 VOT tokens, from -35 ms to +35 ms, were created from the Spanish paf-. They were then attached to the final Spanish –ri in order to create the Spanish set, preserving the Spanish /ɾ/ (a flap). The English set was created by attaching the same VOT variations to the final English –ɾɨ, preserving the English /ɹ/ (a retroflex). Bilinguals and monolinguals

---

2 Gonzales and Lotto (2013) used the term *language-specific phonetic systems* in their original article. In this study, however, I have decided to refer to the same set of skills as *language-specific perceptual strategies* since L2 learners may develop these skills in their learning process.
participated in the Spanish and English contexts and were asked to indicate which word they heard. The results showed that, in the phonetic space in which English and Spanish overlap (within the short-lag VOT values), bilinguals (but not monolinguals) were able to shift their perception of the sounds, depending on the language context, even though they were exposed to the same VOT continuum. For instance, bilinguals identified significantly higher instances of voiceless sounds (\textit{pafri}) in Spanish than in English language mode. On the other hand, monolinguals failed to shift boundary in the same contexts. Gonzales and Lotto stated that bilinguals had shown language-specific perceptual strategies, triggered by extrinsic language cues, such as phonetic cues (the Spanish /r/ and the English /r/) and/or expectations about the language to be heard.

Language context has been shown to produce effects even before conscious perception, indicating that language-specific perceptual strategies could occur in early auditory processing. García-Sierra et al. (2012) investigated changes in electrical brain activities through mismatch negativity (MMN) experiments (e.g., MMN responses increase as acoustic memory trace and acoustic deviant differences increase). Spanish-English bilinguals read magazines and interacted with researchers in their language of interest. They were exposed to a VOT continuum ranging from /ga/ to /ka/. The results showed that bilinguals produced MMN amplitudes that were different depending on the language context. In the Spanish condition, bilinguals perceived -20 ms and +15 ms VOT variations as different phonemic categories (/ga/ and /ka/), yielding the presence of the MMN. In the English condition, bilinguals perceived the same VOT values as belonging to the same phonemic category (/ka/ and /ka/), yielding absence of MMN. García-Sierra et al.’s study supports the hypothesis that bilinguals possess language-specific perceptual strategies, even in the previous stages of language processes.
The studies discussed in this section have contributed to the understanding of how bilingual minds work, and a great number of them have shown that highly fluent bilinguals are able to demonstrate that they possess language-specific perceptual strategies (e.g., they operate in different modes, depending on the language context). Although it has been stated that “highly confident L2 bilinguals […] are more likely to possess a double phonemic representation” (García-Sierra et al., 2009, p. 378), and that “presumably, more competent bilinguals overcome this clash of phonetic systems” (Gonzales & Lotto, 2013, p. 2135), in fact, it is not clear whether late L2 learners with limited access to L2 input would display language-specific perceptual strategies in ways similar to highly proficient bilinguals. The present study addresses this question by investigating if late L2 learners who have learned L2 in a formal setting in their L1 country would shift their phonemic boundary when processing sounds in L2 and L1 modes. If this group of L2 learners is able to demonstrate these skills, this study will show that the acquisition of language-specific perceptual strategies is also possible for this population, despite the obvious challenges (e.g., limited exposure to L2 input). More specifically, this study aims to investigate whether L2 perception of VOT values shifts across levels of proficiency when learners are presented with ambiguous stimuli (e.g., short-lag VOT values) as a function of language mode. Therefore, the present study can make a major contribution to the understanding of how languages are processed and retrieved by L2 learners, especially when L2 learners encounter sounds that overlap in the L1-L2 phonetic space, but may refer to different phonemic categories in their two languages.

The next section discusses relevant research in L1 phonetic drift, focusing on the possible influences of L2 VOT learning on perception and production of L1 consonant stops. In this study, L1 phonetic drift refers to the effects of the acquisition of an L2 on an L1. The potential
effects of the acquisition of an L2 on an L1 are measured by comparing the Portuguese production and perception habits of monolingual Portuguese speakers with those of native Portuguese speakers who are learning English as an L2.

### 2.4 L2 Learning of VOT Production and Perception: L1 Phonetic Drift

Much of L2 research focuses on the influence of L1 on L2; on the other hand, a number of studies have shown cross-language phonetic influences (e.g., Chang, 2011; Flege; 1987; Lev-Ari & Peperkamp, 2013; Lord, 2008; Major, 1992; Sancier & Fowler, 1996). These studies suggest that the “L1 system does not become static and invariable, but instead remains dynamic and ever-changing” (Chang, 2011, p. 250). This L1 phonetic drift (or attrition) in VOT values, that is, the effects of the acquisition of an L2 on the production and perception of L1, has been most observed in late bilinguals (e.g., Lev-Ari & Peperkamp, 2013; Lord, 2008; Major, 1992), and, more recently, among less experienced bilinguals (Chang, 2011). A great number of such studies have focused on L2 learners who were living in the country where the target language is spoken. For instance, Chang (2011) investigated Americans learning Korean in Korea; Lev-Ari and Peperkamp (2013) investigated Americans learning French in France; Major (1992) investigated American learners of Portuguese who had immigrated to Brazil. Other studies have focused on L2 learners who were highly proficient in their L2. Flege (1987) investigated French professors in an American university; Lord (2008) investigated Spanish professors and graduate students of Spanish in the U.S. Fewer studies, however, have investigated the influences of L2 on L1 VOT production and perception among late learners who have learned L2 in a formal context in their L1 country. It has been argued that “findings from naturalistic learning contexts have been somehow hastily generalized to formal learning contexts” (Muñoz, 2010, p. 39).
the other hand, it is possible to assume that, in most countries where English is taught as a foreign language, L2 learners might just never get enough natural input in L2 in order for L2 to influence their L1. The present study aims to contribute to this discussion, since its focus is on the acquisition of L2 in a formal context in the L1 country.

Despite the relatively great number of studies on L1 phonetic drift, the assumption that L2 influences L1 is still controversial. For instance, whereas L1 phonetic drift has been observed among L2 learners, some studies have shown that participants may fail to demonstrate L2 influences on their native language. In Flege’s (1991) study, L2 learners were asked to read Spanish and English words in carrier phrases. Whereas late learners of English (those who had learned English as adults) produced “compromise” VOT values for English /t/ (i.e., their English /t/ had significantly shorter VOT values than English monolinguals, but longer than those produced by Spanish monolinguals), native Spanish speakers who learned English early in life (at ages 5-6) produced VOT values for English /t/ that did not differ from those of monolingual English speakers. However, both groups of learners produced Spanish /t/ that did not differ significantly from Spanish monolinguals (no evidence of L1 phonetic drift). This study showed that adult L2 learners are more likely to produce intermediate VOT values than early L2 learners, and that the L1-L2 interference can be unidirectional (only L1 was influenced by L2), at least for some learners.

Nevertheless, much research has shown that L2 learning may influence the perception and production of L1 stops. According to Pavlenko (2000), current research has suggested that “the human perceptual system remains somewhat flexible throughout the life course and carries out modifications in response to changes in sensory input” (p. 179). Flege (1987) investigated the production of initial /t/ in English and French words by American women living in Paris, and by
French women living in Chicago (10 years living in the L2 country for both groups of women). Their production of /t/ in their L1 displayed influences of L2 learning. For instance, native French participants produced French /t/ with longer VOT values than French monolinguals (more English-like), and the native English speakers, who had more experience with French (e.g., more exposure to the French spoken by native speakers than the other proficient groups in the study), produced English /t/ with shorter VOT values (more French-like). Similar results were also found among Americans living in Brazil. Major (1992) analyzed the production of English and Portuguese stops in words and in sentences by five adult Americans who had emigrated to Brazil. All of them demonstrated L1 phonetic drift in their production of stops, showing “loss of native English proficiency” (Major, 1992, p. 200).

Even learners who remained in their L1 community have demonstrated L1 phonetic drift in their production of L1 stops. Lord (2008) investigated the production of English and Spanish words by native English speakers with advanced proficiency in Spanish who lived in the U.S. Their production of English /k/ was significantly shorter, but not their production of /p t/, which resembled those of the monolingual English speakers. The L2 learners’ production of Spanish /p t k/, on the other hand, had native-like VOT values. Although only five L2 learners participated in this study, its result suggests that English /k/ might be more susceptible to being influenced by L2 learning than other voiceless stops.

Studies on the interactions of L1-L2 phonetic systems in code-switching can also shed some light on understanding the role of language context in L1 phonetic drift. Olson (2013) analyzed the effects of language switching in the production of stops by highly proficient English-Spanish bilingual speakers. In order to avoid effects of connected speech (e.g., planning, pragmatics), which may obscure underlying phonetic interactions, Olson elicited code switching
in a cued picture-naming task with initial /k/ in English and Spanish words. Participants were instructed to name the pictures in the language corresponding to the color in the background: Red in English and blue in Spanish for half of the participants, and the inverse color-language pairing for the other half. In this experiment, bilinguals were divided into Spanish-dominant and English-dominant groups. There were three different conditions: Monolingual English context (95% English tokens and 5% Spanish tokens), monolingual Spanish context (95% Spanish tokens and 5% English tokens), and bilingual context (50% English tokens and 50% Spanish tokens). Tokens were divided into two types: Switch tokens (the language of response was different from the immediately preceding token) and stay tokens (no changes in languages between the response and the preceding token).

Olson (2013) observed that effects of language switching on phonetic production were found only in the monolingual contexts. There was a shift in production of L1 VOT in the direction of L2 VOT; no opposite patterns were found. In addition, no effects of language switching in the bilingual context were found. Olson suggests that the unidirectional transfer into L1 by bilinguals could be explained through the Inhibitory Control Model (ICM), a model for bilingual lexical selection. According to this model (Green, 1986), words in the nontarget language are inhibited, which can result in asymmetrical temporal delay. Olson proposed that, at the phonetic level, inhibition could result in asymmetrical transfer: “When switching into the L1, residual inhibition on the previously inhibited L1 phonetic system leads to L2 to L1 transfer. However, when switching into the L2, there was previously little inhibition required on the L2 system, and as such switching into the L2 leads to ‘seamless’ access of the L2 phonetic norms and no L1 to L2 transfer” (p. 418). However, in the bilingual context, the symmetrical results (no difference between the switch tokens and the stay tokens) were prompted by similar levels of
inhibition. Olson acknowledged that “a phonetic-level ICM is tentative at best” (p. 418) and more research is needed.

Not only highly fluent bilinguals, but also novice L2 learners have demonstrated changes in L1 stops. Chang (2011) investigated stops produced by English speakers enrolled in six-week elementary Korean classes in Korea. Data were collected five times during this period. Chang observed shifts in the VOT values. For instance, English voiceless stops increased VOT significantly, showing influences of the Korean voiceless stop. These changes occurred twice (between weeks 1 and 2, and weeks 4 and 5). This study demonstrated that L1 phonetic drift in the production of L2 stops can occur after just some days of L2 exposure.

Although a few studies have failed to demonstrate L1 phonetic drift on stop consonants (e.g., Flege, 1991), the influence of L2 on L1 has been observed in various contexts, for instance, among L2 learners who live in the target-language speaking country (e.g., Chang, 2011; Lev-Ari & Peperkamp, 2013), and among those who live in an L1 community (e.g., Lord, 2008). It has also been observed among novice learners (Chang, 2011), and among fluent L2 learners (e.g., Sancier & Fowler, 1996), as well as in code-switching (e.g., Olson, 2013). Therefore, the influence of L2 knowledge on L1 perception and production of stops seems to be rather pervasive. The present study aims to complement the research in this area of inquiry by investigating the possibility of L1 phonetic drift in the perception and production of L1 VOT values by L2 learners with limited exposure to L2 input who have acquired English in a formal context. Comparisons were conducted between perception and production of Portuguese by L2 learners of English and monolingual Brazilian Portuguese across different levels of proficiency. Ultimately, this portion of the study aims to contribute to the overall understanding of the L1 phonetic drift by adding scientific information on the dynamic nature of the L1-L2 relationship.
2.5 Summary

Studies on the L2 learning of VOT production and perception have shown that L2 learners, especially early bilinguals, are able to establish new phonetic categories in production (e.g., Flege, 1987), and that highly fluent bilinguals are able to shift their perception of the phonetic boundary of stops according to the language mode (e.g., Gonzales and Lotto, 2013). More recent studies (e.g., Chang 2011) have also shown that L2 can affect the production of L1 stops, even in the first weeks of L2 learning. The current study aims to contribute to this discussion by analyzing the perception and production of the L2 English and L1 Portuguese stops in initial position by Brazilian Portuguese learners of English who learned English as a foreign language in their home country in a formal context. For instance, this study aims to investigate whether proficiency would affect perception and production of L2 stops, and whether L2 learners were able to maintain separate categories for the production of stops in both their L2 and their L1. It also aims to investigate whether L2 learners who had learned their L2 in a formal setting were able to demonstrate that they had developed language-specific perceptual strategies for VOT categories, a skill that highly fluent bilinguals have been shown to possess (Gonzales & Lotto, 2013). The next chapter presents a detailed description of the general methods, including descriptions of the participants, the settings, and the procedures.
CHAPTER 3 – GENERAL METHODS FOR ALL EXPERIMENTS

3.1 Introduction

This study considers the perception and production of L2 English and L1 Portuguese stops in initial position by Brazilian Portuguese (BP) learners of English and monolingual BP speakers. It aims to investigate whether proficiency affects L2 VOT perception and production, and whether L2 learners are able to maintain separate distributions for the production of L2 and L1 stops. It also aims to investigate whether L2 learners demonstrate L1 phonetic drift in their perception and production of stops, and whether L2 learners are able to demonstrate that they possess language-specific perceptual strategies when processing the stimuli in their first language Portuguese and in their second language English. This dissertation includes 4 studies: 2 delayed repetition tasks, one in L1 and one in L2, were conducted to elicit the production data. 2 two-alternative forced-choice (2AFC) tests, one in L1 and one in L2, were conducted to elicit the perception data. (The English and Portuguese experiments were mirror-images of each other.) This chapter describes the parts of the methods that are general to all of the experiments, particularly the participants’ characteristics, the settings, and the overall experimental procedures.

3.2 Participants

3.2.1 L2 Learners

There were a total of 36 Brazilian Portuguese learners of English recruited in this study (26 female, 10 male), whose age ranged from 18 to 50 years old ($M = 29.55$). The same L2 learners participated in all studies. All participants had at least a high school degree (25 of them
were in college and 4 had taken graduate-level courses). All participants were born in the city of Araxá, Minas Gerais, except two, who were born in São Paulo and Rio de Janeiro, respectively. They were all living in Araxá, except one participant who was living in Governador Valadares (a city located in the same state of Minas Gerais). All participants reported having normal hearing, and normal or corrected vision.

3.2.1.1 L2 learners’ Proficiency Levels

All L2 learners took part in an English language proficiency test – the St. George International Online English Test, obtained online (see Appendix A). The St. George International Online English Test was chosen because the results obtained in this test could be compared to the Common European Framework of Reference for Languages (CEFR). CEFR was developed to establish international standards for language assessment and teaching in Europe and has been applied in the assessment of modern language proficiency since the 1970s. CEFR divides the levels of proficiency into three levels of users: basic, independent, and proficient (see Appendix B). This language test, therefore, provides relatively reliable results in terms of the test takers’ levels of proficiency. However, the emphasis of the test is on grammar, not on oral production.

The online test was assessed by the researcher, along with a native English speaker, who was a trained teacher in English as a second language. After their assessment of the test, questions 4, 19, and 29 were slightly modified in order to avoid either ambiguity or bias toward British or American dialects (e.g., in question 19, needn’t and needn’t have were changed to don’t need to and didn’t need to). In order to estimate the test difficulty and the time L2 learners would require to complete it, a few Brazilian Portuguese learners of English who were living in
Brazil took the English language proficiency test. Their impression of the test was that it was relatively balanced between easy and difficult questions. They took around 20 minutes to complete the test.

The mean of the English language proficiency test taken by the 36 L2 learners participating in this study was 26.94 (maximum possible score: 40), the median was 27.5, and the mode was 31. The standard deviation was 8.82. The lowest score was 10 (25%) and highest score was 40 (100%), yielding a statistical range of 30. Overall, the scores on the test were somehow skewed, with a skewness of -0.19. The Kurtosis shows that the distribution of scores was in some way flat, with a value of -1.241. The skew and the Kurtosis of the proficiency test indicates that, in general, students did well on the test: A little more than half of the participants (55.55%) scored 30 or below, and a little less the half of the participants (44.44%) scored above 30 (i.e., above 75% on the test). The graphical display of the scores is presented in Figure 3.1 and the summary of the results is presented in Table 3.1.
Figure 3.1. Distribution of scores obtained by L2 learners (Brazilian Portuguese learners of English) on the English language proficiency test (maximum possible score: 40).

Table 3.1

<table>
<thead>
<tr>
<th>Descriptive Statistics for the English Language Proficiency Test.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of participants</td>
</tr>
<tr>
<td>Number of items</td>
</tr>
<tr>
<td>Maximum possible score</td>
</tr>
<tr>
<td>Mean</td>
</tr>
<tr>
<td>Median</td>
</tr>
<tr>
<td>Mode</td>
</tr>
<tr>
<td>Standard deviation</td>
</tr>
<tr>
<td>Skewness</td>
</tr>
<tr>
<td>Kurtosis</td>
</tr>
<tr>
<td>Range</td>
</tr>
<tr>
<td>Minimum</td>
</tr>
<tr>
<td>Maximum</td>
</tr>
</tbody>
</table>
A decision was made in order to have the participants in two groups of proficiency with an equal number of subjects in each (lower and higher). The cut-off value was 27, which roughly corresponds to the cut-off between intermediate and upper intermediate, according to the distribution of levels from the Council of Europe’s Common European Framework (their cut-off is 29). Therefore, 18 L2 learners were placed in the lower-proficiency group (L) and 18 were placed in the higher-proficiency group (H). (See Appendix C for individual scores and their correspondent group of proficiency.)

3.2.1.2 L2 Language Background Questionnaire

L2 learners answered a language background questionnaire (see Appendix D for its Portuguese version, and Appendix E for its English version). It included questions about their experiences with foreign languages, their self-perception of their English abilities, their use of English, and their motivation. The questionnaire was partially based on Elliott (1995) and Díaz Granado (2011). It was given in Portuguese in order to guarantee that all participants, including beginners, could provide their information accurately. Information from their language background questionnaire is summarized in Table 3.2. Characteristics of the lower- (L) and higher-proficiency (H) groups, reported on the language background questionnaire, are analyzed and reported below. The information provided by the L2 learners in the language background questionnaire is also discussed in the next sections.
Table 3.2

**Background Information (Ms, SDs, Ranges) of the L2 Learners (Brazilian Portuguese Learners of English), According to Their Level of Proficiency.**

<table>
<thead>
<tr>
<th>Gender</th>
<th>Age</th>
<th>Acq.</th>
<th>% Use English in at school</th>
<th>Length of Learning</th>
<th>Contact with NS</th>
<th>LEC</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Lower-Proficiency Group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 (f)</td>
<td>29.11</td>
<td>21.06</td>
<td>79.44</td>
<td>3.02</td>
<td>15 (never)</td>
<td>18 (never)</td>
</tr>
<tr>
<td>5 (m)</td>
<td>(9.08)</td>
<td>(9.38)</td>
<td>(24.00)</td>
<td>(1.66)</td>
<td>3 (yes)</td>
<td></td>
</tr>
<tr>
<td>19-47</td>
<td>9-44</td>
<td>0-100</td>
<td>0.41-7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Higher-Proficiency Group</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13 (f)</td>
<td>30.56</td>
<td>11.39</td>
<td>81.11</td>
<td>9.94</td>
<td>10 (never)</td>
<td>14 (never)</td>
</tr>
<tr>
<td>5 (m)</td>
<td>(9.53)</td>
<td>(2.85)</td>
<td>(23.19)</td>
<td>(7.27)</td>
<td>8 (yes)</td>
<td></td>
</tr>
<tr>
<td>18-50</td>
<td>6-17</td>
<td>0-100</td>
<td>2-21</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Note.** f (female); m (male); Age (current age in years); Acq. (age of acquisition); Length of Learning (in years) includes continuous and non-continuous study of English; Contact with NS (whether participants have had contact with native speakers of English); LEC (whether participants have lived in an English-speaking country).

### 3.2.1.2.1 Age and Gender

Both L2 learner groups had the same number of male and female participants, 13 females and 5 males in the L and the H groups. In order to investigate if there was a difference in age mean between L and H groups, an independent samples t-test was conducted. It showed that there was no significant difference in age between the L group ($M = 29.11; SD = 9.08$) and the H group ($M = 30.56; SD = 9.53$) conditions; $t(34) = 0.465, p > 0.05$.

### 3.2.1.2.2 Age of Acquisition

Various studies indicate that the age of first exposure to L2 influences the overall success of the acquisition of a second language in naturalistic settings (e.g., Flege, Schirru, & MacKay, 2003). However, in a foreign language context, age of first exposure might not be as relevant.
Muñoz (2010) argues that, when researching L2 language acquisition as a foreign language, it is important to distinguish between age of first exposure and age of acquisition. For her, age of first exposure to a foreign language might represent “only insignificant exposure” (p. 44), whereas age of acquisition is related to the beginning of significant exposure to L2. In this study, Brazilian Portuguese learners of English were first exposed to English either in a private English school, or as part of their regular curriculum at school. Participants were asked to report the age they felt was more significant for them in terms of learning. Following Muñoz, the age considered here is the age L2 learners judged to be their age of acquisition (meaningful exposure to L2), which is then considered the starting point of their L2 acquisition.

In order to determine if age of acquisition of English had any effect on their current proficiency, an independent samples t-test was conducted. There was a significant difference in age of acquisition between the lower-proficiency group (\(M = 21.06; SD = 9.38\)) and the higher-proficiency group (\(M = 11.39; SD = 2.852\)); \(t(20.11) = 4.182, p < 0.001\). (Because Levene’s test of equality of variances revealed that the homogeneity of variance was not to be assumed, values from Equal Variances not Assumed are reported.) Although there were overlaps between the L or the H groups, the L group had much more variation, and a fair number of learners who reported their age of acquisition as being 18 or over: 12 learners out of 18. (See Appendix F for the distribution of age of acquisition by levels of proficiency.) All L2 learners from the H group, on the other hand, reported their age of acquisition as being under 18 years old. Therefore, the H group started learning English significantly earlier in life than the L group.
3.2.1.2.3 Knowledge of Another Foreign Language, Experience Abroad, and Contact with Native Speakers

Of the 36 participants, 12 (33.33%) reported having some knowledge of French, Spanish, or Italian besides English: 8 in the H group and 4 in the L group. They had studied these languages in Brazil from 1 month to 5 years. These languages, however, have VOT categories similar to the Portuguese language. Therefore, this knowledge cannot affect the results of the study. The majority of participants, 24 (66.66%), had never studied another foreign language besides English. None of them reported being fluent in another language besides English and Portuguese.

Only four L2 learners, all in the H group, had had the opportunity to stay in an English-speaking country for a longer time: 4 L2 learners had stayed in the U.S. for 6 months, 9 months, 1 year, and 3 years, respectively. Five L2 learners had visited some English-speaking country for a few days. The majority (27 learners out of 36) had never visited another country, including all L2 learners in the L group.

Their contact with native speakers was rather limited. A large number of L2 learners (25 out of 36) had never had contact with native speakers of English. The ones that had some contact with native speakers were: 4 learners who had lived abroad (all in the H group), 5 who reported they had had a native English speaker as a teacher or as a colleague at school (3 in the H group and 2 in the L group), and two who said they had contact with native speakers online (1 from the L group and 1 from the H group).
3.2.1.2.4 Length of Learning

Along with age of acquisition, it is important to investigate how long L2 learners have studied English. As expected, an independent samples $t$-test revealed that there was a significant difference in length of learning (in years) between the lower-proficiency group ($M = 3.02; SD = 1.66$) and the higher-proficiency group ($M = 9.94; SD = 7.27$); $t(18.77) = 3.93, p < 0.05$.

(Because Levene’s test of equality of variances revealed that the homogeneity of variance was not to be assumed, values from Equal Variances not Assumed are reported.) L2 learners who had studied English for a longer time were more advanced in their L2 acquisition.

In sum, the L2 language background questionnaire revealed, that L2 learners had not had much opportunity to interact with native speakers of English; the H group differed significantly from the L group in age of acquisition (the H group started earlier), but not in terms of chronological age, and that the H group had studied English longer than the L group.

3.2.1.2.5 Self-Perception of L2 Use

Participants were asked to estimate in percentage how much English they currently used in certain situations and places (at language school, at home [e.g., homework], on the Internet, at work, watching movies/videos, with friends, and with online classes). Studies have reported that L2 use correlates with levels of proficiency (e.g., Gatbonton & Trofimovich, 2008). In order to determine whether learners’ differences in proficiency (L and H groups) are affected by differences in L2 use of English, an independent samples $t$-test was conducted. The mean comparison showed that there was a significant difference in the use of L2 English between the lower-proficiency group ($M = 31.74; SD = 11.69$) and the higher-proficiency group ($M = 47.37; SD = 19.74$).
\( SD = 14.68 \); \( t(34) = 3.53, p < 0.05 \). (See Appendix G for the distribution of use of English by levels of proficiency.) The H group used L2 English significantly more often than the L group.

### 3.2.1.2.6 Self-Perception of English Skills

Participants were asked to estimate their English abilities (speaking, writing, listening, grammar, vocabulary, pronunciation, reading) by choosing a number from 1 (very low) to 7 (excellent). The summary of their responses (\( Ms \) and \( SD \)) is shown in Appendix H. A series of independent samples \( t \)-tests was conducted for each of the self-reported English skills in order to determine if there was any difference in means between the L and the H groups.

The result showed that there was no significant difference in the self-reported L2 English skills for the L and H groups in any of the English skills \((p > 0.05)\). The mean for the seven values per group were: Speaking (L = 3.78; H = 4.39); Writing (L = 4.44; H = 4.5); Listening (L = 4.44; H = 3.89); Grammar (L = 4.33; H = 4.39); Vocabulary (L = 4.33; H = 4.56); Pronunciation (L = 4.67; H = 4.33); and Reading (L = 4.61; H = 5). This result showed that both L and H groups were homogenous in terms of self-perception of their L2 English skills. It might be the case that either (a) the H group underestimates their proficiency or (b) the L group overestimates their proficiency. An alternative possibility is that there is a lot of individual variation in each group. In any case, since in this study L2 learners’ self-assessment of L2 language skills was not to be counted as a variable affecting L2 proficiency groups, no further discussion on the topic was addressed.
3.2.1.2.7 Self-Perception of Motivation

Although a foreign language teacher and an L2 learner would agree that motivation plays a key role in achieving success in another language, it is not clear what effects motivation has on pronunciation. Some studies have reported that motivation exerts some influence on L2 learners’ pronunciation. Elliott (1995) found that success in having a native-like pronunciation was primarily related to learners’ motivation and desire to have accurate pronunciation. Although most studies have reported some influence of motivation on the degree of L2 foreign accent, motivation (e.g., professional motivation, integrative motivation) does not automatically prevent L2 learners from having a foreign accent (Piske, MacKay, & Flege, 2001). The relative importance of motivation on the degree of foreign accent, however, is rather uncertain, mainly because studies have not quantified motivation precisely, and because of the possibility of confounding. For instance, Nagle (2013) stated that although motivation is important for L2 pronunciation, “the exact nature of that motivation remains unclear” (p. 150), and that motivation may be confounded with, for instance, amount of language experience. Nevertheless, motivation is seen by some as “one of the main determinants of second/foreign language learning achievement” (Dörnyei, 1994, p. 273).

In this study, L2 self-perception of motivation was assessed by asking participants to respond to seven statements related to motivation in a Likert-scale going from 1 (strongly disagree) to 7 (strongly agree). (See Appendix I for the summary of responses.) Possible differences on self-perception of motivation between the L and H groups were analyzed through a series of independent samples t-tests. Of the seven statements, only statement 6 (When I speak English, I try my best to not use Portuguese.) had a significant result, showing that there was a difference between the lower- (M = 5.28; SD = 1.22) and higher-proficiency groups (M = 6.33;
The H group avoided Portuguese when speaking English significantly more often than the L group, according to L2 learners’ self-reporting. (See Appendix J for the distribution of responses.) This result, nevertheless, could still be due to chance because there are a lot of parallel comparisons between the L and H groups.

In conclusion, the L2 language background questionnaire showed that the H group differed significantly from the L group in the following ways: they started learning English earlier; they studied English for a longer time; they tried to avoid Portuguese more often when speaking English; and they tended to use English more frequently in their daily lives at the time of the testing.

### 3.2.2 Monolingual Brazilian Portuguese Speakers

There were a total of 36 monolingual Brazilian Portuguese speakers (26 females, 10 males). On average, monolingual Brazilian Portuguese speakers were an older group ($M = 33.08$): their ages ranged from 18 to 65. They were all born in the state of Minas Gerais: 21 participants were born in the city of Araxá and 15 were born in different locations in the same state. They all were living in Araxá when the data collection was conducted. Most of them were studying in a college or had already graduated (15 participants); others were taking graduate-level courses (13 participants), and some had a high school degree (8 participants). All participants reported having normal hearing and normal or corrected vision.

A small number of monolingual Brazilian Portuguese speakers had had some English classes (4 participants). Following Chang (2011), care was taken in defining L1 speakers as the monolingual group for the analysis of Portuguese stops. In order to be sure that these few
participants were, in fact, monolinguals, the researcher asked them to produce any English sentence, which they were unable to do. Therefore, they were included in the monolingual group.

3.3 Settings

The data from the L2 learners were collected in quiet rooms at two English schools in the city of Araxá (Minas Gerais), in the southeastern part of Brazil. The goal was to control for language context in an attempt to prompt L2 learners to process the sounds in L2 English (e.g., it has been demonstrated that salient objects in the environment affect participants’ perception of sounds [e.g., Hay & Drager, 2010; Magloire & Green, 1999]).

The data from the monolingual Brazilian Portuguese speakers were collected in a quiet room at a local college in the city of Araxá (Brazil), where some of its students, professors, and employees participated. Some other monolingual speakers from the community also participated; their data were collected in a quiet room at the home of the researcher’s family, also in Araxá (Brazil).

3.4 General Procedures

L2 learners participated in two language sessions, an English session followed by a Portuguese session. Each language session consisted of two consecutive experiments, a production test followed by a perception test. After finishing the English session, the Portuguese session was conducted either on the same day or on another day, depending on the participants’ availability. The English and Portuguese sessions were mirror-images of each other; that is, both the Portuguese and the English production and perception experiments were designed and conducted in a similar manner, except that one session was in English and the other was in
Portuguese. In general, the English session lasted about 35 minutes, and the Portuguese session lasted about 25 minutes. When L2 learners finished both language sessions, they were instructed to answer the English language proficiency test (see Appendix A) and the language background questionnaire (see Appendix D for the Portuguese version and Appendix E for the English version). Each participant took about one hour to one hour and twenty minutes to complete all the tasks. At the end of the data collection, each participant received a small notebook as a gesture of gratitude.

A native English speaker (the research assistant), who was born and raised in New York City, and who had been trained by the researcher, conducted the English session. The researcher, who was a native Brazilian Portuguese speaker, born and raised in Araxá, where the data collection took place, conducted the Portuguese session. Since English language context is much harder to elicit in a non-English speaking country, all the sessions started with the English portion first. Participants had their first contact only with the native English speaker, while the Portuguese speaker waited in a different room. When the English session was over, the research assistant would call the researcher to conduct the Portuguese session. The research assistant would then stay in a different room. Eliciting Portuguese language mode was, presumably, not difficult since learners could immediately feel comfortable when talking to the researcher, who shared not only their native language, but also their regional dialect. Nevertheless, the researcher always initiated the Portuguese session by having a short dialogue with the participants in Portuguese in order to guarantee that the Portuguese mode was well-established.

Monolingual Brazilian Portuguese speakers participated only in the Portuguese session. After finishing the production and perception experiments, they were asked to answer a
background questionnaire (see Appendix K for the Portuguese version and Appendix L for the English version). Each of the participants received a small notebook as a gesture of gratitude.

The decision about the order of the experiments (the production task first, followed by the perception test) was made based on the level of difficulty reported by the first L2 learner who participated in the study. He had done the perception test first, and he reported that he felt the perception test was much more difficult than the production task. In addition, having the participants take the production task first would strengthen the language context, helping learners to be more attuned to English for the perception test, which required a higher level of sensitivity to language mode. Finally, since the production task was perceived as an easier task, it is hypothesized that taking it first could help learners relax and feel more comfortable with the entire process.

In the following chapters, the production (Chapter 4) and perception (Chapter 5) studies are explained in detail. In the next chapter, the material, the stimuli, the procedures, the acoustic measurements, the analyses, and the results of the production study are discussed.

---

3 This participant was excluded from the analyses.
CHAPTER 4 - PRODUCTION DATA

4.1 Introduction

This study analyzes the production of word-initial English and Portuguese /p t k g/ by Brazilian Portuguese learners of English and monolingual Brazilian Portuguese (BP) speakers in a delayed repetition task. The acoustic correlate examined is VOT. Comparisons among different levels of proficiency and between L2 learners and monolingual groups were conducted. This information revealed whether L2 learners improved their production of L2 VOT values as they progressed in their learning, whether their production of VOT values in Portuguese displayed L1 phonetic drift (i.e., effects of L2 on L1), and whether L2 learners were able to maintain separate distributions for the production of L2 English and Portuguese stops. This chapter describes the design and procedures of the production study (a delayed repetition task), and how the data were collected and then analyzed. Finally, this chapter reports the results and discusses the findings.

Although, phonemically, both English and Portuguese distinguish stops in initial position as being either voiced (/b d g/) or voiceless (/p t k/), English and Portuguese employ different phonetic cues for voiced-voiceless distinction: English phonemically voiced stops are produced with short-lag VOT values, usually no more than 30 ms, and voiceless stops are produced with long-lag VOT values, from 58 to 80 ms (Lisker & Abramson, 1964). Portuguese phonemically voiced stops, on the other hand, are typically prevoiced, that is, produced with the vibration of the vocal folds, and Portuguese phonemically voiceless stops are produced with short-lag VOT values (Alves, 2011).

There are three research questions for the production data. Research Question 1 concerns whether proficiency affected L2 English stops. It was hypothesized that only the higher-
proficiency learners would be able to produce L2 VOT values that would be more English-like, showing sensitivity to language context. For instance, they would demonstrate lengthening of VOT for L2 voiceless stops and would have more instances of short-lag VOT values for L2 /b g/, showing improvement in the production of L2 stops in relation to the lower-proficiency learners. In order to test this hypothesis, comparisons of the production of the L2 English VOT values between L and H group were conducted. Research Question 2 concerns whether Portuguese VOT production was affected by L2 learning. It was hypothesized that L2 learners of English would demonstrate L1 phonetic drift in their Portuguese production of stops. In order to test this hypothesis, comparisons of the Portuguese production of stops between L2 learners of English and monolingual Brazilian Portuguese speakers were conducted. Finally, Research Question 3 concerns whether L2 learners maintained separate distributions for the production of L2 English and Portuguese stops. It was hypothesized that only the higher-proficiency learners would be able to maintain separate distributions for the production of L2 English and Portuguese stops. In order to test this hypothesis, comparisons of the production of stops produced by L2 learners in English and Portuguese were conducted.

4.2 Method

4.2.1 Participants

Participants in the delayed repetition task were Brazilian Portuguese speakers who were learning English as a foreign language and monolingual Brazilian Portuguese speakers. The attributes of the participants are reported in General Methods For All Experiments (Chapter 3).
4.2.2 Stimuli

The stimuli for the delayed repetition task were English and Portuguese words with initial /p b k g/ produced in two different phonological environments, followed by either a low vowel or by a high vowel⁴. There were 10 words for each target phoneme (10 words x 4 target phonemes x 2 phonological environments = 80 words for each condition, that is, 80 words in English and 80 words in Portuguese). All the words were minimal pairs or near minimal pairs since it was impossible to find the same number of perfect minimal pairs in both languages. Examples of English words are peach/beach and cool/goose. Examples of Portuguese words are pingo/bingo (drop/bingo) and quinto/quincho (fifth/winch). The complete list of English words is shown in Table 4.1, and the complete list of Portuguese words, followed by their respective translation in English, is shown in Table 4.2. An attempt was made to use more frequent words, but the researcher had to add some words that were rather uncommon in both languages in order to have the same number of words in each environment. This, however, was not expected to be a problem for L2 learners since, along with the auditory stimuli, participants were also exposed to the correspondent orthographic form of the words and also conceptually related pictures in order to facilitate the task.

The stimuli for the production data, both in Portuguese and English, were recorded on separate days in a sound-proof booth at the Arizona Applied Phonetics Lab at the University of Arizona, using the following equipment: Fostex DC-R302 3-Channel Audio Mixer and Stereo Recorder and Shure SM10A Headworn Microphone.

---

⁴ Phonological environment was not considered a factor in this study. First, the effects of phonological environment (i.e., the following vowel) on the production of VOT are well investigated and documented (e.g., high vowels yield longer VOT values than low vowels) (e.g., Lousada, Jesus, & Hall, 2010; Nearey & Rochet, 1994; Yavas & Wildermuth, 2006). Second, this study does not focus on the VOT variations as the result of phonological environment. Therefore, the researcher decided that there was no need to add phonological environment as an independent variable in the study.
The English and Portuguese words were recorded by two male native speakers, one in each language. The English and Brazilian Portuguese speakers received the same instructions in their respective languages: They were asked to read the instructions for the experiment, followed by a list of words in the carrier phrase, as naturally as possible (English: “[target word] is the word”; Portuguese: “[target word] é a palavra”). They were also asked to produce the question “What is the word?” (“Qual é a palavra?”), which was later added at the end of each carrier phrase. This carrier phrase was chosen because the researcher was interested in a sentence that would be as simple as possible, therefore not adding another layer of difficulty for L2 learners. All the target words were in utterance-initial position in order to control for possible effects of phonological contexts on VOT, such as the presence or absence of voicing in the preceding context, duration of the closure interval, and the speaking rate of a precursor phrase (e.g., Repp & Lin, 1990).

The English and Portuguese native speakers were asked to read the material three times. The recording considered the best by the researcher (e.g., clearer) was then used as stimuli.

4.2.2.1 English Stimuli

All the English words were monosyllabic. Table 4.1 shows the complete list of English words used as stimuli in the delayed repetition task. The words were chosen in consultation with an American English speaker, who is also a phonetician. A native speaker of English born in the Tucson area (Arizona) and a student at the University of Arizona provided the English speech material. He was 22 years old at the time of the recordings and had had some French classes in the past. However, he reported that he could not speak French. Care was taken in order to choose a native speaker who had no knowledge of Portuguese or Spanish, and who could not speak
another foreign language. The sound files were then normalized for pitch intensity at 75db using a Praat script (see Appendix M).

Table 4.1

List of English words used as stimuli in the delayed repetition task.

<table>
<thead>
<tr>
<th>English</th>
<th>/p/</th>
<th>/b/</th>
<th>/k/</th>
<th>/ɡ/</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>pond</td>
<td>bond</td>
<td>cop</td>
<td>goth</td>
</tr>
<tr>
<td></td>
<td>pack</td>
<td>back</td>
<td>car</td>
<td>garb</td>
</tr>
<tr>
<td></td>
<td>par</td>
<td>bar</td>
<td>cot</td>
<td>got</td>
</tr>
<tr>
<td></td>
<td>part</td>
<td>barb</td>
<td>cod</td>
<td>god</td>
</tr>
<tr>
<td></td>
<td>pan</td>
<td>ban</td>
<td>card</td>
<td>guard</td>
</tr>
<tr>
<td></td>
<td>pat</td>
<td>bat</td>
<td>cap</td>
<td>gap</td>
</tr>
<tr>
<td></td>
<td>park</td>
<td>bark</td>
<td>cat</td>
<td>gas</td>
</tr>
<tr>
<td></td>
<td>pox</td>
<td>box</td>
<td>carry</td>
<td>Gary</td>
</tr>
<tr>
<td></td>
<td>pot</td>
<td>bot</td>
<td>cash</td>
<td>gash</td>
</tr>
<tr>
<td></td>
<td>path</td>
<td>bath</td>
<td>cab</td>
<td>gab</td>
</tr>
<tr>
<td></td>
<td>pea</td>
<td>bee</td>
<td>could</td>
<td>good</td>
</tr>
<tr>
<td></td>
<td>pin</td>
<td>bin</td>
<td>kill</td>
<td>gill</td>
</tr>
<tr>
<td></td>
<td>peep</td>
<td>beep</td>
<td>kilt</td>
<td>guilt</td>
</tr>
<tr>
<td></td>
<td>peach</td>
<td>beach</td>
<td>kick</td>
<td>gig</td>
</tr>
<tr>
<td></td>
<td>pig</td>
<td>big</td>
<td>curl</td>
<td>girl</td>
</tr>
<tr>
<td></td>
<td>pit</td>
<td>bit</td>
<td>kit</td>
<td>gift</td>
</tr>
<tr>
<td></td>
<td>pull</td>
<td>bull</td>
<td>kiss</td>
<td>gift</td>
</tr>
<tr>
<td></td>
<td>Pete</td>
<td>beat</td>
<td>cool</td>
<td>goose</td>
</tr>
<tr>
<td></td>
<td>put</td>
<td>book</td>
<td>keys</td>
<td>geese</td>
</tr>
<tr>
<td></td>
<td>push</td>
<td>bush</td>
<td>coo</td>
<td>goo</td>
</tr>
</tbody>
</table>


4.2.2.2 Portuguese Stimuli

All Portuguese words were disyllabic and were stressed on the first syllable. For the selection of the words, the researcher consulted the Dicionário Michaelis de Português UOL (2009) available online. A native Brazilian Portuguese speaker, who was born in São Paulo City, provided the Portuguese speech material. He is a male college student at the University of Arizona, who came to the U.S. through a Brazilian program called Science Without Borders. He was 23 years old at the time of the recordings and had lived in the U.S. for eight months at the time of the recordings. He self-reported as being an intermediate learner of English. Care was taken in order to choose a native Brazilian Portuguese speaker who had lived in the U.S. for a short period of time and whose contacts with the Portuguese language were strong. (The speaker reported that he frequently used Portuguese with his Brazilian friends in town.) The speaker was from the Southeast of Brazil, the same region where the data were later collected, controlling, therefore, for accent variations. The sound files were then normalized for pitch intensity at 75db using a Praat script (see Appendix M).
Table 4.2

List of Portuguese words, followed by the translation in English, used as stimuli in the delayed repetition task.

<table>
<thead>
<tr>
<th>Portuguese</th>
<th>/p/</th>
<th>/b/</th>
<th>/k/</th>
<th>/g/</th>
</tr>
</thead>
<tbody>
<tr>
<td>panda (panda)</td>
<td>banda (band)</td>
<td>calo (I shut up)</td>
<td>galo (rooster)</td>
<td></td>
</tr>
<tr>
<td>pata (paw)</td>
<td>bata (smock)</td>
<td>cato (I pick up)</td>
<td>gato (male cat)</td>
<td></td>
</tr>
<tr>
<td>pato (duck)</td>
<td>bato (I hit)</td>
<td>cala (You shut up)</td>
<td>gala (pomp)</td>
<td></td>
</tr>
<tr>
<td>pano (cloth)</td>
<td>banho (bath)</td>
<td>cama (bed)</td>
<td>gama (gamma)</td>
<td></td>
</tr>
<tr>
<td>paca (paca)</td>
<td>baga (berry)</td>
<td>cala (you pick up)</td>
<td>gata (female cat)</td>
<td></td>
</tr>
<tr>
<td>pala (visor)</td>
<td>bala (taffy)</td>
<td>cana (sugar cane)</td>
<td>gana (desire)</td>
<td></td>
</tr>
<tr>
<td>palha (straw)</td>
<td>balha (to be cited)</td>
<td>canso (I get tired)</td>
<td>ganso (goose)</td>
<td></td>
</tr>
<tr>
<td>pasta (file)</td>
<td>basta (enough)</td>
<td>castro (a name)</td>
<td>gasto (stomach)</td>
<td></td>
</tr>
<tr>
<td>Papa (Pope)</td>
<td>baba (drool)</td>
<td>case (you marry)</td>
<td>gaze (gauze)</td>
<td></td>
</tr>
<tr>
<td>passo (step)</td>
<td>baço (spleen)</td>
<td>cabo (cable)</td>
<td>gabo (I praise)</td>
<td></td>
</tr>
<tr>
<td>pia (sink)</td>
<td>Bia (a name)</td>
<td>quinto (fifth)</td>
<td>guincho (winch)</td>
<td></td>
</tr>
<tr>
<td>pica (it bites)</td>
<td>bica (it bites)</td>
<td>quilha (keel)</td>
<td>guilha (fraud)</td>
<td></td>
</tr>
<tr>
<td>picho (graffiti)</td>
<td>bicho (animal)</td>
<td>quina (corner)</td>
<td>guina (diverge)</td>
<td></td>
</tr>
<tr>
<td>pilha (battery)</td>
<td>bilha (pitcher)</td>
<td>quica (kick)</td>
<td>guiga (a boat)</td>
<td></td>
</tr>
<tr>
<td>pinga (a drink)</td>
<td>binga (horn)</td>
<td>quincha (quincha)</td>
<td>guincha (it tows)</td>
<td></td>
</tr>
<tr>
<td>pico (I bite)</td>
<td>bico (beak)</td>
<td>quita (pay off)</td>
<td>guita (money)</td>
<td></td>
</tr>
<tr>
<td>pingu (drop)</td>
<td>bingo (bingo)</td>
<td>Quito (Quito)</td>
<td>Guido (Guido)</td>
<td></td>
</tr>
<tr>
<td>pulo (I jump)</td>
<td>burro (donkey)</td>
<td>cuspa (you spit)</td>
<td>gume (edge)</td>
<td></td>
</tr>
<tr>
<td>puxa (you pull)</td>
<td>bucha (sponge)</td>
<td>cudo (kudu)</td>
<td>Guto (Guto)</td>
<td></td>
</tr>
<tr>
<td>puxo (I pull)</td>
<td>bucho (stomach)</td>
<td>cura (cure)</td>
<td>gula (voracity)</td>
<td></td>
</tr>
</tbody>
</table>

4.2.2.3 Pictures as Stimuli

Along with the auditory stimuli, participants saw the orthographic form of the word on the screen, and a picture which represented the word in some way (see Appendix N for some
examples). The goal was to assure that all learners, independently of their level of proficiency, would be able to repeat the words (e.g., beginners might have encountered unfamiliar words). Since participants might have known or not known the words they were repeating, the delayed repetition task could potentially show learning over the course of the experiment. Therefore, adding pictures would make the task more meaningful to them. However, the main goal of using the pictures was an attempt to increase the learners’ motivation, helping them to be more alert and engaged with the task.

All the pictures used in the delayed repetition task were creative commons or in the public domain. The pictures were extracted from Clker (n.d.), Hatasa (2003), Image Public Domain Clip Art (n.d.), Sherman (n.d.), Snodgrass and Vanderwart (1980), and Szekely et al. (2004). Care was taken in order to choose pictures that were black and white, simple and basic (e.g., outline drawings), and as unambiguous as possible. They all were approximately the same size and occupied a central location on the screen.

### 4.2.3 Procedures

Delayed repetition tasks have been used in L2 studies as a way to elicit L2 productions (e.g., Aliaga-García & Mora, 2009; Flege & Eefting, 1987a). In this study, the delayed repetition task, both in English and Portuguese, was done through PsychoPy Software (Peirce, 2014) and conducted using the researcher’s personal computer (MacBook Air, 2011). The participants’ productions were recorded using a Fostex DC-R302 3-Channel Audio Mixer and Stereo Recorder and a Shure SM10A Headworn Microphone. The sound was adjusted for the participants’ comfort.
First, participants took part in the English session, which was conducted solely by the research assistant (a native English speaker who had been trained by the researcher). The English session was followed by the Portuguese session, which was conducted solely by the researcher (who is a native Brazilian Portuguese speaker). The research assistant or the researcher explained the experiment to the participants in the respective language in focus and verified whether they understood the task. When the participants felt they were ready, the experiment began. Participants heard (and saw on the screen) the instructions, either in English or in Portuguese:

You will hear some English sentences.

Repeat the first sentence, according to the example. Example:

Speaker: “TABLE is the word. What is the word?”

You: “TABLE is the word.”

Click SPACE to start.

After pressing the spacebar, participants saw a fixation cross for 0.5 seconds, followed by three initial practice trials. (No words with initial stops were included in the practice trials.) After another fixation cross (0.5 seconds), a block of 80 randomly ordered trials was presented, followed by a final fixation cross and a thank-you message. After pressing the spacebar, participants did not have to touch the computer again; they just had to concentrate on the repetition. The sentences presented to the participants were presented only one time.

Both English and Portuguese experiments had the same procedures and duration, except that the time set up for the participants to repeat the Portuguese sentences was a little shorter than the time set up for the English sentences (0.6 and 0.7 seconds respectively). This decision was made because reducing the time for their native language Portuguese would reduce boredom. In the following sections, I describe how the production data was analyzed.
4.2.4 Analysis

Participants were asked to repeat 80 randomized words with initial /p b k g/ in English and Portuguese in carrier phrases: From L2 learners, 2,880 words in English and 2,880 words in Portuguese were produced. From monolingual BP speakers, 2,880 Portuguese words were produced. A total of 8,640 words were generated.

The data collected from the delayed repetition tasks were analyzed using Praat version 5.3.65 (Boersma & Weenink, 2014). First, sound files with individual sentences were sliced from the original sound files through the function Annotate to TextGrid and a script in Praat (see Appendix O). Then the VOT boundaries for each individual sound file were marked: The interval for the positive VOT was signaled by a sharp spike denoting a release burst in the waveform; the boundaries were marked from the first upward zero crossing to the last upward zero crossing, where the regular voice pulse in the waveform started, indicating the onset of voicing. The interval for the negative VOT exhibited regular waves prior to the release burst, and the boundaries were marked from the first upward zero crossing of the periodic waves to the first sharp spike in the waveform denoting a release burst. In the Praat TextGrid, the first tiers were point tiers. The first tier was used to mark the release burst. The second tier was used to mark the onset of periodicity or modal phonation. The last two tiers were used to annotate the following information: The third tier was used to type the target word, and the fourth tier was used to annotate whether the target stop was followed by either a low or a high vowel. The VOT boundaries were marked with the help of a Praat script (see Appendix P).

The information obtained by the tiers was then exported to an Excel spreadsheet through a Praat script (see Appendix Q). The Praat script extracted the time values of the landmarks of tiers one and two as well as the annotations of tiers three and four. Voice onset time was defined
as the time difference between the landmarks in tiers one and two. In particular, VOT was calculated as the time of articulatory release (landmark in tier 1) minus the time of the onset of periodicity (landmark in tier 2). This value, initially in seconds, was multiplied by 1,000 in order to obtain time values in milliseconds (ms). A negative VOT value indicates that the stop was prevoiced; i.e., the onset of voicing preceded the time of articulatory release. A positive VOT value indicated that the VOT was not prevoiced and, in fact, it could have been aspirated; i.e., the onset of voicing followed the time of articulatory release. A long positive VOT value most likely indicated that a stop was significantly aspirated. Figures 4.1, 4.2, 4.3, and 4.4 show examples of the four stops in English and Portuguese investigated in the data.
Figure 4.1. Examples of L2 English VOT measurements for negative VOT. At the top, the English /b/ in the word *back* (VOT duration is -99.17 ms); at the bottom, the English /g/ in the word *gap* (VOT duration is -109.16 ms). The portion between the small vertical mark in the first and second tiers was measured as the VOT.
Figure 4.2. Examples of L2 English VOT measurements for positive VOT. At the top, the English /p/ in the word *pig* (VOT duration is 24.06 ms); at the bottom, the English /k/ in the word *cat* (VOT duration is 41.70 ms). The portion between the small vertical mark in the first and second tiers was measured as the VOT.
Figure 4.3. Examples of Portuguese VOT measurements for negative VOT produced by monolingual speakers. At the top, the Portuguese /b/ in the word *bala* “candy” (VOT duration is -102.81 ms); at the bottom, the Portuguese /g/ in the word *galo* “rooster” (VOT duration is -73.42 ms). The portion between the small vertical mark in the first and second tiers was measured as the VOT.
Figure 4.4. Examples of Portuguese VOT measurements for positive VOT produced by monolingual speakers. At the top, the Portuguese /p/ in the word *pato* “duck” (VOT duration is 13.62 ms); at the bottom, the Portuguese /k/ in the word *quinto* “fifth” (VOT duration is 60.47 ms). The portion between the small vertical mark in the first and second tiers was measured as the VOT.
4.3 Results

4.3.1 L2 English VOT Production by L2 Learners

RQ1. Does proficiency affect the production of L2 English stops?

The data produced by L2 learners in the delayed repetition task addressed whether general improvement in L2 language entailed improvement in production of phonetic categories of Brazilian Portuguese learners of English (RQ1). Improvement in L2 VOT means a lengthening of lag VOT in the voiceless category and possibly a reduction of prevoicing in the voiced categories. It is hypothesized that the L2 proficiency levels would affect English VOT production. For instance, the H group, but not the L group, would produce L2 English VOT values that approximate those of the target language. This result would demonstrate improvement in the production of English VOT categories, and would show that L2 VOT categories may be acquired, even in conditions of formal foreign language instruction and limited exposure to L2 input.

The data from L2 learners in the delayed repetition task yielded a total of 2,880 English words (10 words x 4 stops x 2 phonological environments x 36 participants). In order to determine improvement of VOT categories among L2 learners, their production data of L2 English was compared with the L and the H proficiency groups. The data on the L2 English production by BP learners of English were analyzed using a (2)x2 mixed-design ANOVA, with voicing (voiced, voiceless) as the within-subjects factor, and proficiency group (L, H) as the between-subjects factor. The VOT measurements were the dependent variable. This was a
continuous variable expressed in milliseconds (ms). The analysis was performed first for bilabials /p b/, and then for velars /k g/.\(^5\)

4.3.1.1 Bilabials: /p/-/b/

As shown in Figure 4.5, the difference, on average, in the production of L2 English bilabials between the L and H groups was rather small, with the H group showing a tendency to have longer VOT values for /p/ and longer negative VOT values for /b/ than the L group.

\(^5\) VOT values are expected to vary systematically in relation to place of articulation (e.g., the further back the closure, the longer the VOT; the faster the movement of the articulators, the shorter the VOT). Therefore, VOT is shorter for bilabials than for velars, independent of whether they are aspirated or not (e.g., Cho & Ladefoged, 1999). Since these effects are expected, and are not of interest in the present study, bilabials and velars were analyzed as two separate groups.
Figure 4.5. Overall results of L2 English VOT production of bilabials. L2 learners (Brazilian Portuguese learners of English), mean VOT production of L2 English bilabials by voicing (voiceless, voiced), and proficiency group (lower, higher).

There was a significant main effect of voicing \((F(1, 34) = 362.98, p < 0.001)\), but there was no main effect of proficiency group \((F<1)\). The two-way interaction was not significant (proficiency group by voicing: \(F(1, 34) = 1.73, p > 0.05\)). No difference between the L group (for voiceless, \(M = 18.10; SD = 14.92\); for voiced, \(M = 90.16; SD = 36.64\)) and the H group (for voiceless, \(M = 25.70; SD = 18.99\); for voiced, \(M = 98.62; SD = 34.28\)) was found. The only significant difference was in voicing, which was as expected: /b/ was significantly prevoiced and /p/ had a short-lag VOT. Therefore, L2 learners did not demonstrate the effects of proficiency levels in the production of L2 English bilabials.
4.3.1.2 Velars: \(/k/-/g/\)

As shown in Figure 4.6, the H group produced, on average, slightly longer VOT values for \(/k/\) and longer negative VOT values for \(/g/\) than the L group, although the difference was not large.

![L2 VOT Production of Velars by Proficiency Group](image)

**Figure 4.6.** Overall results of L2 English VOT production of velars. L2 learners (Brazilian Portuguese learners of English), mean VOT production of L2 English velars by voicing (voiceless, voiced), and proficiency group (lower, higher).

There was a significant main effect of voicing ($F(1, 34) = 388.13, p < 0.001$), but no main effect of proficiency group ($F<1$). The two-way interaction was significant (proficiency group by voicing: $F(1, 34) = 5.40, p < 0.05$). In the follow-up tests, the simple effect of
proficiency group was checked for each level of voicing (voiced, voiceless). There was no simple effect of proficiency group for either /k/ ($F(1, 34) = 3.63, p > 0.05$) or /g/ ($F(1, 34) = 2.23, p > 0.05$) in L2 English. The production of the /k/ ($M = 59.04; SD = 17.27$) and the /g/ ($M = -55.44; SD = 43.58$) produced by the L group, and the /k/ ($M = 70.09; SD = 17.55$) and the /g/ ($M = -74.99$ and $SD = 34.44$) produced by the H group were not significantly different.

The mean values produced by the L and H groups for phonologically English voiced sounds revealed that L2 learners were producing a more Portuguese-like /g/ in their L2 English since the sound was prevoiced. Their production of L2 /k/ seems to be more English-like than Portuguese-like. Melo, Mota, Mezzomo, Brasil, Lovatto, and Arzeno (2014) reported a mean VOT value for Portuguese /k/ of 45.4 ms.

RQ1 addressed the following question: Does proficiency affect the production of L2 English stops? It was hypothesized that higher-proficiency L2 learners would demonstrate the production of L2 VOT values more similar to what is expected from native English speakers than lower-proficiency learners. Since no significant difference in L2 English VOT production between the L and H proficiency groups was found, this hypothesis was not satisfied.

In sum, the analysis of the L2 English production of bilabials and velars produced by BP learners of English and revealed by VOT did not demonstrate effects of proficiency level (RQ1). Therefore, in order to address RQ2 and RQ3, the lower-proficiency group (18 participants) and the higher-proficiency group (18 participants) were pooled together as one group (36 participants), henceforth called L2 learners, since both the L and H groups did not demonstrate differences in terms of production of initial L2 English stops.

---

6 Additional follow-up ANOVA tests were conducted, with language proficiency (L, H) as the between-subjects factor. The difference between the mean VOT values of /g/ and /k/ from each subject was the dependent factor. The main effect of language proficiency was not significant ($F<1$), confirming no effects of language learning in the production of L2 VOT English velars.
4.3.2 Portuguese VOT Production by L2 Learners of English and Monolingual BP Speakers

RQ2. Is L1 Portuguese production of stops affected by L2 learning?

The data produced by monolingual Brazilian Portuguese speakers were used to determine whether L1 phonetic drift had occurred in the production of L1 Portuguese by L2 learners of English (RQ2). If the production of Portuguese by L2 learners differs from the production of monolingual Brazilian Portuguese (e.g., the Portuguese /p/ stops produced by L2 learners have longer lags than those produced by monolinguals, going in the direction of English VOT values), then L1 phonetic drift will have been observed. It is expected that the production of Portuguese stops by Brazilian Portuguese learners of English will be affected by L2 learning (e.g., Chang, 2011; Cook, 2003; Lord, 2008; Major, 1992; Sancier & Fowler, 1996).

The Portuguese data from monolingual BP speakers and from L2 learners in the delayed repetition task yielded a total of 5,760 Portuguese words (10 words x 4 stops x 2 phonological environments x 72 participants). In order to determine whether L1 phonetic drift occurred in the L2 learners’ production of Portuguese, a comparison between the production of Portuguese by L2 learners and monolingual BP speakers was conducted. The data on the Portuguese production from L2 learners and the control group (monolingual BP speakers) were analyzed using a (2)x2 mixed-design ANOVA, with voicing (voiceless, voiced) as the within-subjects factor, and language group (control group, L2 learners) as the between-subjects factor. The VOT measurements were the dependent variable. This was a continuous variable expressed in milliseconds (ms). The analysis was performed first for bilabials /p b/, and then for velars /k g/.
4.3.2.1 Bilabials: /p/-/b/

As shown in Figure 4.7, on average, there was no difference between the L2 learners and the control group for Portuguese /p/. L2 learners, however, produced longer negative VOT values for Portuguese /b/ than the control group, although this difference does not seem to be too large.

![Portuguese VOT Production of Bilabials](image)

**Figure 4.7.** Overall results of Portuguese VOT production of bilabials. L2 learners (Brazilian Portuguese learners of English), and the control group (monolingual Brazilian Portuguese speakers), mean VOT production for Portuguese bilabials by voicing (voiceless, voiced), and language group (control group, L2 learners).

There was a significant main effect of voicing ($F(1, 70) = 1,875.65, p < 0.001$), but the main effect of language group was not significant ($F(1, 70) = 2.35, p > 0.05$). The two-way interaction was significant (voicing by language group: $F(1, 70) = 6.01, p < 0.05$). In the follo
up tests, the simple effect of language group was checked for each level of voicing (voiced, voiceless). There was a significant simple effect of language group for voiced \((F(1, 70) = 4.05, p < 0.05)\), but no simple effect of language group for voiceless \((F(1, 70) = 2.16, p > 0.05)\).\(^7\)

Results from the analysis of Portuguese VOT production of bilabials by L2 learners of English showed that there was no difference between the monolingual BP \((M = 11.10; SD = 5.40)\), and BP learners of English \((M = 13.14; SD = 6.38)\) for the production of Portuguese \(/p/\). However, these two groups showed a significant difference regarding the production of Portuguese \(/b/\). L2 learners produced Portuguese \(/b/\) with significantly longer negative VOT \((M = -119.06; SD = 26.00)\) than the control group \((M = -106.93; SD = 25.11)\), that is, farther from zero.

### 4.3.2.2 Velars: \(/k/-/g/\)

As shown in Figure 4.8, on average, for the Portuguese production of \(/g/\) and \(/k/\), L2 learners produced longer positive VOT values for \(/k/\) than monolingual BP speakers, and longer negative VOT values for \(/g/\) than monolingual BP speakers.

\(^7\) Additional follow-up ANOVA tests were conducted, with language group (L2 learners, control group) as the between-subjects factor. The difference between the mean VOT values of \(/b/\) and \(/p/\) from each subject was the dependent factor. The main effect of language group was not significant \((F(1, 70) = 2.35, p > 0.05)\), showing no effects of language group in the production of Portuguese bilabials.
Figure 4.8. Overall results of Portuguese VOT production of velars. L2 learners (Brazilian Portuguese learners of English), and the control group (monolingual Brazilian Portuguese speakers), mean VOT production for Portuguese velars by voicing (voiceless, voiced), and language group (control group, L2 learners).

There was a significant main effect of voicing ($F(1, 70) = 2.454.76, p < 0.001$), but there was no main effect of language group ($F(1, 70) = 1.15, p > 0.05$). The two-way interaction was significant (voicing by language group: $F(1, 70) = 12.25, p < 0.05$). In the follow-up tests, the simple effect of language group was checked for each level of voicing (voiceless, voiceless). There was a significant simple effect of language group for the two levels of voicing (voiceless: $F(1, 70) = 8.38, p < 0.05$; voiced: $F(1, 70) = 6.68, p < 0.05$).\(^8\)

---

\(^8\) Additional follow-up ANOVA tests were conducted, with language group (L2 learners, control group) as the between-subjects factor. The difference between the mean VOT values of /g/ and /k/ from each subject was the
These results showed that the monolingual BP speakers and L2 learners of English differ in terms of Portuguese VOT production of /k/ and /g/: L2 learners produced longer positive VOT values for Portuguese /k/ (\(M = 63.05; SD = 11.06\)), and longer negative VOT values for Portuguese /g/ (\(M = -102.38; SD = 21.57\)) than the control group (\(M = 55.30; SD = 11.63; M = -88.30; SD = 24.57\)).

RQ2 addressed the following question: *Is L1 Portuguese production of stops affected by L2 learning?* It was hypothesized that the production of L1 Portuguese by BP learners of English would be different from the monolinguals, displaying L1 phonetic drift. This hypothesis was partially satisfied since the effects of L2 learning on the production of L1 Portuguese stops was found in /b k g/, but not in /p/.

In sum, the analyses of the Portuguese VOT production by Brazilian Portuguese L2 learners of English and monolingual Brazilian Portuguese speakers suggested that the production of Portuguese bilabials and velars by the L2 learners may have been affected by L2 learning of English for /b/, /g/, and /k/, but not for /p/. The analyses suggest that L2 knowledge may play a role in the Portuguese VOT production of L2 learners of English, since L2 learners differ from the control group. L2 learners produced longer negative Portuguese VOT values for /b/ and /g/, and longer positive Portuguese VOT values for /k/ than the control group. L2 learners seem to be exaggerating their Portuguese /b/ and /g/, making it even more distant from English and more distant from the monolingual Portuguese speakers. However, for /k/, L2 learners are doing the reverse and letting their Portuguese get closer to the English target. Although the directions of these effects seem to be conflicted at first glance, the fact that participants were making all VOTs more extreme might have been a strategy to make all distinctions clearer. Therefore, the dependent factor. The main effect of language group was not significant (\(F<1\)), showing no effects of language group in the production of Portuguese velars.
production of Portuguese stops by the L2 learners displayed L1 phonetic drift, showing effects of L2 learning (RQ2).

4.3.3 Portuguese and L2 English VOT Production by L2 Learners

RQ3. *Do L2 learners maintain separate distributions for the production of L2 English and L1 Portuguese stops?*

In order to determine whether the differences between the L2 learners and the control group were due to the formation of new VOT categories in L2 learners’ production, comparisons were conducted between the production of stops produced by L2 learners in English and Portuguese language modes. If L2 learners show that they have lengthened the VOT in the phonologically voiceless category and possibly reduced the prevoicing in the phonologically voiced categories for L2 English, then L2 learners will have suggested the formation of new VOT categories in their L2 production. Therefore, this analysis will investigate whether L2 learners have developed separate categories for the production of L2 English and Portuguese VOT.

The data yielded a total of 5,760 English and Portuguese words (2,880 words for each language mode) (10 words x 4 stops x 2 phonological environments x 2 language modes x 36 participants). The data were analyzed using a (2)x(2) within-subjects ANOVA design, with language modes (Portuguese, English) and voicing (voiceless, voiced) as the within-subjects factors. The VOT measurements were the dependent variable. This was a continuous variable expressed in milliseconds (ms). The analysis was performed first for bilabials /p b/, and then for velars /k g/. Since no difference in production between the L group and the H group was found (RQ1), all the L2 learners were pooled together as one group.
4.3.3.1 Bilabials: /p/-/b/

As shown in Figure 4.9, L2 learners, on average, produced /p/ with longer VOT values in L2 English than in Portuguese. They also produced shorter negative VOT values for /b/ in L2 English than in Portuguese.

![VOT Production of Bilabials by L2 Learners](image)

**Figure 4.9.** Overall results of L2 learners’ production of L2 English and Portuguese VOT bilabials. L2 learners (Brazilian Portuguese learners of English), mean VOT production for bilabials by voicing (voiceless, voiced), and language mode (Portuguese, English).

The statistical analysis showed that there was a significant main effect of language mode ($F(1, 35) = 22.77, p < 0.001$) and a significant main effect of voicing ($F(1, 35) = 682.72, p < 0.001$). The two-way interaction was also significant (language mode by voicing: $F(1, 35) = 12.06, p < 0.005$).
Since there was an interaction, the simple effect of language mode was checked for each voicing level (voiceless, voiced). The results showed that there was a significant simple effect of language mode for the /p/ ($F(1, 35) = 10.267, p < 0.05$), and a significant simple effect for the /b/ ($F(1, 35) = 22.09, p < 0.001$). L2 learners produced longer positive VOT values for their L2 English /p/ ($M = 21.90; SD = 17.27$) than for their Portuguese /p/ ($M = 13.14; SD = 6.38$). They also produced shorter negative VOT values for their L2 English /b/ ($M = -94.39; SD = 35.23$) than for their Portuguese /b/ ($M = -119.06; SD = 26.00$). These results suggest that L2 learners were able to keep separate VOT categories for /b/ and /p/ for these two languages (e.g., their L2 English /b/ and /p/ were more English-like).

4.3.3.2 Velars: /k/-/g/  

As shown in Figure 4.10, there was no difference, on average, in the production of /k/ in L2 English and Portuguese modes by L2 learners. However, L2 learners produced /g/ with shorter negative VOT values in L2 English than in Portuguese.
Figure 4.10. Overall results of L2 learners’ production of L2 English and Portuguese VOT velars. L2 learners (Brazilian Portuguese learners of English), mean VOT production for velars by voicing (voiceless, voiced), and language mode (Portuguese, English).

The statistical analysis showed that there was a significant main effect of language mode ($F(1, 35) = 25.34, p < 0.001$) and voicing ($F(1, 35) = 857.86, p < 0.001$). The two-way interaction was also significant (language mode by voicing: $F(1, 35) = 37.59, p < 0.001$). In the follow-up tests, the simple effect of language mode was checked for each level of voicing (voiceless, voiced). For /k/, the result was non-significant ($F<1$). However, there was a significant simple effect for /g/ ($F(1, 35) = 33.23, p < 0.001$).\(^9\) In other words, L2 learners did not maintain separate distributions for /k/ in L2 English ($M = 64.56; SD = 18.05$) and Portuguese ($M$

---

\(^9\) Additional follow-up ANOVA tests were conducted, with language modes (Portuguese, English) as the within-subjects factor. The difference between the mean VOT values of /g/ and /k/ produced in English and in Portuguese for each subject was the dependent factor. The main effect of language mode was not significant ($F<1$), showing no effects of language mode in the production of velars.
= 63.05; SD = 11.06), since no significant difference was found. For /g/, L2 learners kept separate categories: L2 learners produced shorter negative VOT values in English (M = -65.21, SD = 39.96) than in Portuguese (M = -102.38; SD = 21.55).

RQ3 addressed the following question: Do L2 learners maintain separate distributions for the production of L2 English and L1 Portuguese stops? It was hypothesized that highly proficient learners (but not lower-proficiency learners) would be able to maintain separate distributions for the production of L2 English and Portuguese stops. This hypothesis was partially satisfied: No difference between levels of proficiency was found (RQ1). In addition, L2 learners demonstrated maintenance of separate distributions for the production of L2 English and Portuguese for the stops /p b g/, but not for the stop /k/.

In sum, L2 learners kept separate categories when producing /p b g/, but not /k/. L2 learners produced longer VOT values for /p/ in L2 English than in Portuguese. They also produced longer negative VOT values for Portuguese /b/ and for Portuguese /g/ than in the corresponding L2 English sounds, demonstrating a more English-like production of stops in L2.

4.4 Discussion

The production data were elicited through a delayed repetition task in the respective monolingual language mode (either English or Portuguese). The mean and range of the VOT measurements of the bilabials and velars produced by all participants are summarized in Table 4.3.
Table 4.3

Mean (first line) and range (second line) of VOT production of initial bilabials and velars by each language group (the control group [monolingual Brazilian Portuguese speakers] and L2 learners [Brazilian Portuguese learners of English]). Values are presented in milliseconds.

<table>
<thead>
<tr>
<th></th>
<th>L1 PORTUGUESE</th>
<th></th>
<th>L2 ENGLISH</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Monolinguals</td>
<td>L2 Learners</td>
<td>L2 Learners</td>
</tr>
<tr>
<td></td>
<td>Bilabials</td>
<td>Velars</td>
<td>Bilabials</td>
</tr>
<tr>
<td></td>
<td>/p/</td>
<td>/k/</td>
<td>/p/</td>
</tr>
<tr>
<td></td>
<td>11.10</td>
<td>55.27</td>
<td>21.90</td>
</tr>
<tr>
<td></td>
<td>(-154.73 to 88.31)</td>
<td>(-173.67 to 148.06)</td>
<td>(-352.58 to 121.42)</td>
</tr>
<tr>
<td></td>
<td>/b/</td>
<td>/g/</td>
<td>/b/</td>
</tr>
<tr>
<td></td>
<td>-106.95</td>
<td>-88.36</td>
<td>-94.34</td>
</tr>
<tr>
<td></td>
<td>(-263.73 to 36.45)</td>
<td>(-228.06 to 118.48)</td>
<td>(-276.01 to 123.54)</td>
</tr>
</tbody>
</table>
There are a number of studies that have focused on the Portuguese and L2 English VOT production by BP learners of English (e.g., Alves & Zimmer, 2015; Cohen, 2004; França, 2011; Major, 1987; Reis & Nobre-Oliveira, 2007; Rocca, 2003).\(^\text{10}\) The Portuguese and L2 English VOT production of BP learners of English, shown in Table 4.3, can be compared with results obtained in previous studies. For an overall comparison, Table 4.4 and Table 4.5 show a list of mean VOT values (in ms) of Portuguese and L2 English stops produced by BP learners of English and obtained from previous studies, alongside the results obtained in the present study.

Table 4.4

\textit{Mean VOT values (in ms) of Portuguese stops, produced by Brazilian Portuguese learners of English, in initial position, obtained from a number of studies.}

<table>
<thead>
<tr>
<th>Brazilian Portuguese stops (produced by BP learners of English)</th>
<th>/p/</th>
<th>/b/</th>
<th>/k/</th>
<th>/g/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rocca (2003)</td>
<td>10.37</td>
<td>--</td>
<td>43.73</td>
<td>--</td>
</tr>
<tr>
<td>França (2011)</td>
<td>19.56</td>
<td>--</td>
<td>47.20</td>
<td>--</td>
</tr>
<tr>
<td>Present study</td>
<td>13.14</td>
<td>-119.06</td>
<td>63.05</td>
<td>-102.38</td>
</tr>
</tbody>
</table>

\(^{10}\) Not all studies provide the overall VOT mean production of stops.
Table 4.5

*Mean VOT values (in ms) of L2 English stops, produced by Brazilian Portuguese learners of English in initial position from a number of studies.*

<table>
<thead>
<tr>
<th>L2 English stops</th>
<th>/p/</th>
<th>/b/</th>
<th>/k/</th>
<th>/g/</th>
</tr>
</thead>
<tbody>
<tr>
<td>(produced by BP learners of English)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rocca (2003)</td>
<td>58.00</td>
<td>--</td>
<td>80.00</td>
<td>--</td>
</tr>
<tr>
<td>França (2011)</td>
<td>27.43</td>
<td>--</td>
<td>58.61</td>
<td>--</td>
</tr>
<tr>
<td>Present study</td>
<td>21.90</td>
<td>-94.34</td>
<td>64.56</td>
<td>-65.17</td>
</tr>
</tbody>
</table>

The number of studies focusing on Brazilian Portuguese VOT production produced by adult monolingual BP speakers is rather small (e.g., Alves & Dias, 2010; Klein, 1999; Melo et al., 2014; Silva, 2008). The Portuguese VOT measurements (mean) shown in Table 4.3 can be compared with measurements obtained in previous studies. For an overall comparison, Table 4.6 shows a list of mean VOT values (in ms) of Brazilian Portuguese stops produced in initial position by monolingual BP speakers obtained by a number of previous studies, along with the results obtained in the present study.
Table 4.6

Mean VOT values (in ms) of Brazilian Portuguese stops in initial position produced by monolingual Brazilian Portuguese speakers from a number of studies.

<table>
<thead>
<tr>
<th>Brazilian Portuguese stops (produced by monolingual BP speakers)</th>
<th>/p/</th>
<th>/b/</th>
<th>/k/</th>
<th>/g/</th>
</tr>
</thead>
<tbody>
<tr>
<td>Major (1992)</td>
<td>10.51</td>
<td>--</td>
<td>35.25</td>
<td>--</td>
</tr>
<tr>
<td>Klein (1999)</td>
<td>15.58</td>
<td>-92.27</td>
<td>36.36</td>
<td>-78.20</td>
</tr>
<tr>
<td>Melo et al. (2014)</td>
<td>15.7</td>
<td>-101.9</td>
<td>45.4</td>
<td>-80.4</td>
</tr>
<tr>
<td>Present study</td>
<td>11.10</td>
<td>-106.95</td>
<td>55.27</td>
<td>-88.36</td>
</tr>
</tbody>
</table>

From the results presented in Table 4.6, a number of patterns emerge. For instance, it is well-accepted that the further back the closure, the longer the VOT for voiceless stops, and the faster the movement of the articulator, the shorter the VOT. For instance, tongue movement is faster for alveolar than velars (Cho & Ladefoged, 1999). These patterns can be observed in Portuguese in phonemically voiceless stops: Portuguese /k/ is produced with longer VOT values than Portuguese /p/.

The results shown in Table 4.6 show that the production of /p/ by monolingual BP speakers among various studies, including the present one, had similar VOT values (within short-lag values). The production of /k/, in the present study, had larger VOT values than previous studies. Nevertheless, the VOT values shown in Table 4.6 are in the within-lag VOT value ranges. The results shown in Table 4.4, demonstrated that the production of L2 /p/ stop by

---

11 Possible explanations for these VOT patterns include aerodynamics, movements of articulators, the extent of the articulatory contact, and change of glottal opening area (Cho & Ladefoged, 1999).
BP learners of English in the present study and the other studies have similar results, but L2 /k/ in the present study has a longer mean VOT than the previous studies.

RQ1 addressed the following question: *Does proficiency affect the production of L2 English stops?* It was hypothesized that the L and H groups would demonstrate differences in the production of L2 VOT values. For instance, it was expected that the H group (but not the L group) would produce stops more similar to what it is expected from native English speakers. Since no significant difference in L2 English VOT production between the L and the H proficiency groups was found, this hypothesis was not satisfied.

RQ2 addressed the following question: *Is L1 Portuguese production of stops affected by L2 learning?* It was hypothesized that the production of stops in L1 Portuguese by BP learners of English would be different from the monolinguals. L2 learners were expected to display L1 phonetic drift in their production of Portuguese stops. This hypothesis was partially satisfied since the effects of L2 learning on the production of L1 Portuguese stops was found in /b k g/, but not in /p/.

RQ3 addressed the following question: *Do L2 learners maintain separate distributions for the production of L2 English and L1 Portuguese stops?* It was hypothesized that the H group (but not the L group) would be able to maintain separate distributions for the production of L2 English and Portuguese stops. This hypothesis was partially satisfied since L2 learners (both L and H groups) maintained separate distributions for the production of L2 English and Portuguese for /p b g/, but not for /k/.

In sum, the analyses of data production showed that there was no significant difference between the lower- and higher-proficiency groups in the production of L2 English bilabials and velars (RQ1). Therefore, the lower- and higher-proficiency groups were pooled into a single
group: L2 learners. The subsequent analyses showed that L2 learners demonstrated that they have their Portuguese production affected by the exposure to L2 English when producing Portuguese /b/, /k/, and /g/, but not when producing /p/ (RQ2). L2 learners produced longer negative VOT for Portuguese /b/ and for Portuguese /g/ than did monolingual BP speakers. They also produced longer positive Portuguese VOT values for /k/ than monolinguals. No evidence of L1 phonetic drift was found for the production of /p/. However, when L2 learners’ production of L2 English stops was compared to their production of Portuguese stops, L2 learners maintained separate categories for L2 English and Portuguese for /p/, /b/ and /g/, but not for /k/ (RQ3). L2 learners produced shorter negative VOT values in L2 English than in Portuguese when producing /b/ and /g/. They also produced longer VOT values in L2 English than in Portuguese for /p/. There was no evidence of new VOT category formation for /k/. Table 4.7 summarizes the results for each research question.
Table 4.7

Summary of the results of the production data for each research question.

<table>
<thead>
<tr>
<th>Research Questions</th>
<th>Bilabials</th>
<th>Velars</th>
</tr>
</thead>
<tbody>
<tr>
<td>(RQ1) Does proficiency affect the production of L2 English stops?</td>
<td>NO.</td>
<td>NO.</td>
</tr>
<tr>
<td></td>
<td>NO.</td>
<td>NO.</td>
</tr>
<tr>
<td>(RQ2) Is L1 Portuguese production of stops affected by L2 learning?</td>
<td>NO.</td>
<td>YES.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>YES.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>YES.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>YES.</td>
</tr>
<tr>
<td>(RQ3) Do L2 learners maintain separate distributions for the production of L2 English and L1 Portuguese stops?</td>
<td>YES.</td>
<td>YES.</td>
</tr>
<tr>
<td></td>
<td>NO.</td>
<td>YES.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Proficiency turned out to be irrelevant for the production of L2 English stops. L2 learners (both the L and H groups) were able to establish new VOT categories in L2 (with the exception of /k/), showing effects of L2 learning. These results suggest that the acquisition of L2 in a foreign environment in a formal context (e.g., English classes) and limited exposure to L2 input do not impede L2 learners from establishing new VOT categories. On the other hand, the fact that the H group did not differentiate from the L group might suggest learning stabilization (Han, 2004, 2011, 2013).

The production of Portuguese stops by L2 learners of English and monolingual BP speakers showed that L1 phonetic drift occurred for the production of Portuguese /b/, /g/, and /k/, but not for /p/. This result suggests that, in the acquisition of L2 VOT knowledge, not only L2 phonetic systems, but also L1 phonetic systems, go through processes of self-organization as a result of a bidirectional influence (L1 and L2 influence each other).

A more in-depth discussion of the results from the production data as well as possible implications for research and teaching are discussed in Chapter 6. In the following chapter (Chapter 5), perception studies are explained in detail, including the stimuli, procedures, results, and analyses of the results.
CHAPTER 5 – PERCEPTION DATA

5.1 Introduction

This study analyzed the perception of voice onset time (VOT) word-initially by Brazilian Portuguese (BP) learners of English and monolingual Brazilian Portuguese speakers in a two-alternative forced-choice identification test (2AFC). Comparisons among different levels of proficiency and between L2 learners and monolingual groups were conducted. These analyses informed whether L2 learners’ perception of stops was influenced by their progress in their L2 learning, whether L2 learners displayed L1 phonetic drift (effects of the acquisition of L2 on L1) in the perception of Portuguese stops, and whether L2 learners had developed language-specific perceptual strategies for their L1 (Portuguese) and L2 (English).

Stops in initial position, within short-lag VOT values, are perceived as /b d g/ in languages such as English, Danish, and German; however, the same sounds are perceived as /p t k/ in languages such as Portuguese, Spanish, Arabic, Bulgarian, Russian, Hungarian, French, Polish, Dutch, Greek, and Yiddish (e.g., Keating, 1984; Lisker & Abramson, 1964). More specifically, Portuguese and English contrast stops with the same phonological category (voiced and voiceless), but phonetically, speakers use different phonetic categories: Whereas in initial position, Portuguese /b d g/ are realized as prevoiced sounds, English /b d g/ are most commonly realized with short-lag positive VOT values. English /b d g/ and Portuguese /p t k/ are realized with short-lag, and they are perceived as unaspirated. English /p t k/ are realized with long-lag VOT values, and they are perceived as aspirated. If L2 learners are able to shift their phonetic boundary as a function of language mode (e.g., within short-lag VOT values, Brazilian Portuguese learners of English would perceive the sounds as phonemically voiceless stops in the
English context, but as phonemically voiced sounds in the Portuguese context), then it could be assumed that these L2 learners were able to develop language-specific perceptual strategies. A great number of these studies have demonstrated that, in fact, bilinguals are able to shift boundary when exposed to different language contexts (e.g., Elman, Diehl, & Buchwald, 1977; García-Sierra et al., 2012; Gonzales & Lotto, 2013; Sundara & Polka, 2008).

The perception study follows a tradition of studies that investigate double perceptual boundaries (e.g. Bohn & Flege, 1993; Garcia-Sierra, Diehl, & Champlin, 2009; García-Sierra, Ramírez-Esparza, Silva-Pereyra, Siard, & Champlin, 2012; Gonzales & Lotto, 2013; López, 2012; Williams, 1977). These studies concerned the investigation of L2 VOT perception where L1-L2 phonetic space overlaps. The original works of Caramazza et al. (1973) and Williams (1977) showed that bilinguals were not able to shift phonemic boundary across language contexts. In Caramazza et al. (1973), English-French bilinguals perceived L2 English and L1 French within VOT range that had intermediate values, even though they differed from monolinguals. In Williams (1977), Spanish-English bilinguals, the majority of the participants did not shift their phonetic boundary across language modes within the ambiguous region.

However, a number of subsequent studies have shown that bilinguals are able to shift phonetic boundary as a function of language contexts (e.g., Elman et al., 1977; García-Sierra et al., 2012; Gonzales & Lotto, 2013; Sundara & Polka, 2008). These studies have investigated highly proficient bilinguals, showing that early bilinguals are sensitive to language context and able to shift their perception of stops, according to the language in focus. In Gonzales and Lotto (2013), for instance, Spanish-English highly proficient bilinguals were randomly assigned to either Spanish or English conditions. The stimuli were created from the words *bafri* and *pafri* (nonwords in both languages) and recorded in Spanish and in English. From the Spanish *pafri*, a
A continuum of 14 VOT steps (from -35 ms to +35 ms) was generated. The Spanish set and the English set were created by attaching to the continuum the final Spanish –ri (Spanish /ɾ/ is a flap) and the final English –ri (English /ɹ/ is a retroflex), respectively. Bilinguals and monolinguals were asked to identify the word they heard (bafri or pafri) in the English and Spanish contexts. The result showed that, whereas bilinguals were able to shift their perception of sounds according to the language context, monolinguals were not. For instance, within short-lag VOT values, bilinguals identified more instances of /p/ in Spanish than in English contexts. Therefore, the data suggest that these bilinguals demonstrated that they possess language-specific perceptual strategies, since they were able to process the sounds as L1 or as L2, depending on the language mode.

There is a general assumption that self-reported highly confident L2 bilinguals (those that self-reported being highly confident in speaking, writing, reading, and listening comprehension in two languages) and simultaneous bilinguals (those exposed to two languages from birth) “are more likely to possess a double phonemic representation” (García-Sierra et al., 2009, p. 378), and “presumably, more competent bilinguals overcome this clash of phonetic systems” (Gonzales & Lotto, 2013, p. 2135). However, it is not clear whether language-specific perceptual strategies would also be a set of skills that late L2 learners with limited access to L2 input would possess, for instance, in a foreign language-learning context. The general goal of the present perception study was to investigate this possibility.

There are three research questions for the perception data. Research Question 4 concerns whether proficiency would affect the perception of English stops. It was hypothesized that proficiency would affect the perception of L2 English stops: The H group would be able to shift their phonetic boundary at a higher VOT than the L group in order to perceive an English /p/.
This hypothesis was based on the assumption that early high-proficiency bilinguals and early L2 learners are more likely to develop language-specific perceptual strategies (García-Sierra et al., 2009; Gonzales & Lotto, 2013), and that, as we get older, L1 phonetic categories become stronger attractors of L2 sounds (e.g., Flege, 1987; Flege, 1995; Flege & Eefting, 1987b; Flege, Schirru, & MacKay, 2003). Research Question 5 concerns whether L1 Portuguese VOT perception was affected by L2 learning. It was hypothesized that L2 learning would affect perception of L2 stops. This hypothesis was based on previous studies, which showed that L1 phonetic drift could occur with both novice and highly fluent learners (e.g., Chang, 2011; Flege, 1987; Lev-Ari & Peperkamp, 2013; Major, 1992; Sancier & Fowler, 1996). Research Question 6 concerns whether L2 learners would demonstrate that they have developed language-specific perceptual strategies for VOT categories when processing sounds in their L1 and in their L2. It was hypothesized that the H group (but not the L group) would demonstrate that they have developed language-specific perceptual strategies. This hypothesis was based on previous studies, which indicate that early fluent bilinguals were probably more likely to show such skills (García-Sierra et al., 2009; Gonzales & Lotto, 2013).

In the present study, the same stimuli, created by Gonzales and Lotto (2013), were used. The stimuli were generously provided by Gonzales and Lotto to the researcher. The study broadly followed Gonzales and Lotto’s rationale on the procedures. However, the participants in this study were late L2 learners who had acquired English as a second language in formal settings with limited exposure to L2 input in their L1 country. In Gonzales and Lotto’s study, the participants were early and highly proficient bilinguals. If L2 learners demonstrate the same abilities that early and highly fluent bilinguals have demonstrated, this study will show that language-specific perceptual strategies are also possible for this population, despite the obvious
challenges (e.g., limited input). More specifically, this study aims to investigate whether L2 learners’ perception of VOT shifts across levels of proficiency as a function of language mode, when learners are presented with ambiguous stimuli (short-lag VOT values). Therefore, the present study makes a major contribution to the understanding of how languages are processed and retrieved by L2 learners, especially when L2 learners encounter sounds that overlap in the L1-L2 phonetic space, but may also refer to different phonemic categories in their two languages. This chapter describes the design and procedures of the perception study (a two-alternative forced-choice identification test), the results, and subsequent analyses.

5.2 Method

5.2.1 Participants

The participants in the two-alternative forced-choice identification test were Brazilian Portuguese speakers who were learning English as a foreign language and monolingual Brazilian Portuguese speakers. The attributes of the participants are reported in General Methods For All Experiments (Chapter 3). A decision was made to exclude 12 L2 learners (six from the lower-proficiency group and six from the higher-proficiency group) since they clearly did not process the /b/-/p/ continuum categorically. The criterion used in order to decide which subjects would be included was the following: The percentage of /p/ responses in both endpoints of the continuum in both experiment blocks was obtained. One endpoint was subtracted from the other. Only participants who had more than 50% (0.5 points) difference between the two endpoints were included. For instance, those participants who responded 100% /p/ in one extreme and 60% /p/ in the other extreme were excluded since they do not go through 50% cross-over point. Only participants who maintain the two-endpoint different (more than 50% difference) in both their
modes were included. They seemed to have understood the test better since they were processing the sounds categorically throughout the whole continuum (e.g., they were able to distinguish /b/ and /p/ relatively well). Therefore, the total number of L2 learners considered in the perception study was 24 (12 from the lower-proficiency group and 12 from the higher-proficiency group).

5.2.2 Stimuli

The English and Portuguese stimuli for the two-alternative forced-choice identification test were generously provided by the researchers Kalim Gonzales and Andrew J. Lotto. The stimuli consisted of the same stimuli they used in their 2013 study. Gonzales and Lotto prepared the stimuli in the following way: A Spanish-English bilingual speaker produced the words bafri and pafri in both Spanish and English accents. The initial paf- from the Spanish pafri was detached and used to create a continuum of 14 VOT steps (steps of 5 ms, from -35 ms to +35 ms, skipping 0 VOT). The final –ri, from both Spanish and English versions, was resynthesized to control for duration, F0 onset and contour, preserving the salient features of English /ɹ/ (a retroflex) and Spanish /ɾ/ (a flap). The point is that, since the second syllable –ri of the words pafri and bafri is identifiable as being either from Spanish (or Portuguese) or from English, it is expected that the second syllable would remind the listeners that the voice they were hearing on the stimuli was either speaking Portuguese (when the /ɾ/ is a flap sound) or English (when the /ɾ/ is a retroflex sound). Since the /ɾ/ is distinct enough in these two languages, it was expected that it would provide strong cues to the listeners, helping L2 learners process the sounds according to the respective language in focus, that is, in the expected direction. The English set was created by attaching the final English /æi/ to the 14 VOT steps; the Spanish set was created by attaching
the final Spanish /ɾi/ to the same 14 VOT steps. Therefore, the English and Spanish sets consisted of the same VOT steps.

Although the stimuli from Gonzales and Lotto (2013) were produced by natural speech of a Spanish-English bilingual, they were adequate to be used in this study by Portuguese speakers due to the following reasons:

a. Portuguese and Spanish flaps are similar in a number of ways: Both sounds are described as alveolar flaps and they do not occur word-initially (Cotton & Sharp, 1988; Mateus & d’Andrade, 2000). Flaps can occur as part of a two-consonant cluster (after a consonant in onset position) in Spanish and Portuguese, the same context presented in the stimuli (bafri and pafri). In addition, the words bafri and pafri, which are nonwords in English and Spanish, are also nonwords in Portuguese. They are, however, possible words in the three languages, in the sense that they respect the phonotactic rules of each language.

b. Spanish and Portuguese are phonologically similar, in terms of how both languages use the stops in words. In addition, the voiced-voiceless distinction is similar in both languages: Unlike English, but similar to Spanish, Portuguese speakers prevoice initial /b d g/, and produce initial /p t k/ with short-lag values (e.g., Klein, 1999).

c. Finally, the stimuli were initially presented to a couple of Brazilian Portuguese speakers, including the researcher, who perceptually identified the Portuguese flap in the words bafri and pafri, and recognized them as possible words in the language.

Using the stimuli from Gonzales and Lotto (2013) with a different population provides an excellent opportunity to compare results. In Gonzales and Lotto, the participants were bilinguals who had learned both Spanish and English before 8 years of age and were highly proficient. In this study, the participants were late L2 learners who had learned English in their L1 country.
with limited L2 input. For instance, this study would help to investigate whether or not late L2 learners and highly proficient bilinguals would differ in terms of perceptual sensitivity to the VOT continuum in the phonetic ambiguous region (within short-lag VOT values). Such comparisons will provide important contributions to the understanding of the interaction between L1-L2 phonetic systems.

5.2.3 Procedures

In this study, a two-alternative forced-choice identification test was carried out through the PsychoPy Software (Peirce, 2014) and conducted using the researcher’s computer (MacBook Air, 2011), and AKG K77 Headphones. The sound was adjusted for the participants’ comfort.

Each perception test was conducted after the production tasks were concluded in each language session. (See details of the production task in Chapter 4.) Participants took part in the English session first, which was then followed by the Portuguese session.

In the English session, participants were told that they would hear two English words repeated many times. In the Portuguese session, they were told they would hear the same words but, this time, pronounced in Portuguese. This is a slight modification from Gonzales and Lotto’s (2013), who decided to inform participants that they would hear real words in English and then real words in Spanish. However, participants in this study seemed able to understand the task better when the researcher explained that the same words heard in the English session would then be pronounced in Portuguese.¹² No mention of whether the words were real or imaginary

¹² The first participant had trouble understanding the task. After the researcher had explained that the words he was hearing were the same English words he had heard in the previous session, but now pronounced in Portuguese, the participant could carry on the task. Therefore, the researcher decided to do the same procedure with all future participants. This participant was excluded from the analyses.
was made. In addition, the words *pafri* and *bafri* were never pronounced by the researcher or the research assistant while the tests were being conducted.

When participants felt ready, the experiment started. The instruction recordings were done by the same native speakers who provided the stimuli for the production data. (See details in Chapter 4.) The participant could hear and read the instructions on the screen. The English instructions were as follows:

*You will hear two words in English: BAFRI and PAFRI.*

*If the word starts with B, click the left arrow.*

*If the word starts with P, click the right arrow.*

*Click SPACE to start.*

In the Portuguese session, the instruction was the same, except that it was in Portuguese, and the message said that they would hear Portuguese words. In order to help participants find the right keys on the keyboard, the researcher marked the left arrow with the letter B, the right arrow with the letter P, and the spacebar with the words SPACE or ESPAÇO. As a way to prime language context, the words BAFRI and PAFRI bore the colors of the American and Brazilian flags. For the English session, BAFRI was in red and PAFRI in blue; for the Portuguese session, BAFRI was in green and PAFRI in yellow. In addition, the word *English* and the word *Português* appeared above the words BAFRI and PAFRI on the screen during the data collection, in the English session and in the Portuguese session, respectively (see Appendices T and U for examples of the interface in English and in Portuguese, respectively). The research assistant, a native speaker of English, and the researcher, a native speaker of Portuguese, conducted separate sessions in their respective languages. Participants were told explicitly that they would hear words pronounced in the language in focus. The care taken in the experiment is validated by a
number of studies which have shown that differences in the experimental environment, even small details, can influence participants’ perception on a continuum (e.g., Hay & Drager, 2010; Hay, Nolan, & Drager, 2006; Magloire & Green, 1999). It is hypothesized that controlling the ambient language and the environment would help participants increase sensitivity to the language in focus, priming them to process the sounds in the respective monolingual language mode, i.e., either as Portuguese sounds, in the Portuguese session or as English sounds in the English session (Grosjean, 1985, 1994, 1997, 1998, 2001, 2013).

After listening to the instructions and clicking SPACE, participants saw a fixation cross, which lasted 0.5 seconds. Then, the words were presented to them in a randomized order. There was a 4.1 second timeout, after which the computer played the next stimulus if the subject did not respond before that. The screen, however, did not change. The task ended with a fixation cross (0.5 seconds), followed by a thank-you message.

A couple of times participants interrupted the test to ask a question at the very beginning of the test (e.g., two participants thought there was a problem with the test because they thought they were listening to the same word repeated many times). In these cases, the researcher stopped the experiment, explained the nature of the test once again, and reinstated the experiment. Since this happened only twice, and at the very beginning of the experiment, this was not expected to affect the overall results.

Although the design of the study broadly followed Gonzales and Lotto’s (2013), it was not an exact replication. For instance, in their study, there were three blocks of 14 randomly ordered trials. In this study, there was only one block of 80 randomly ordered trials. This decision was made for two reasons:
a. Increasing the number of tokens would increase the reliability of the results. For instance, it would help compensate for possible mistakes produced by participants in the performance of the task, such as pressing a key by mistake.

b. Having only one block would avoid human error in the analysis of the data. In this experiment, participants saw the word BAFRI always on the left of the screen and the word PAFRI on the right, for both English and Portuguese sessions, whereas in Gonzales and Lotto’s (2013) study, the words were counterbalanced. In the following sections, the results of the data analyses for the perception study are discussed.

5.3 Results

The perception data were elicited through a two-alternative forced-choice identification test (2AFC) done in English and Portuguese modes. In the English mode, the test generated 3,360 responses by L2 learners (14 VOT steps x 10 repetitions x 12 participants x 2 proficiency groups). In the Portuguese mode, the test generated 7,560 responses by L2 learners and BP monolingual speakers (14 VOT steps x 10 repetitions x 54 participants). There was a total of 10,920 responses. In Figure 5.1 and Figure 5.2, the distribution of the data across all conditions is presented for a general comparison. Next, the results of the data analyses are presented and discussed.
Figure 5.1. Distribution of the results of PAFRI identification across all conditions. L2 learners (lower, higher) and the control group (monolingual Brazilian Portuguese speakers), mean proportion of PAFRI identification by language group (control group, lower, higher), and by language mode (Portuguese, English).
Figure 5.2. Overall distribution of the perception data across all conditions. PAFRI identification in the Portuguese and English modes. Lower and higher-proficiency groups of L2 learners (Brazilian Portuguese learners of English), control group (monolingual Brazilian Portuguese), mean proportion of PAFRI identification by language group (control group, lower, higher) and language mode (Portuguese, English) as a function of voice onset time.

5.3.1 English VOT Perception by L2 Learners

RQ4. Does proficiency affect the perception of L2 English stops?

These data addressed the question of whether the lower- and the higher-proficiency groups differed from each other in terms of perception of initial English /b/ and /p/ on a continuum. Examining the group means could address this question. If the H group (but not the L group) categorized the stimuli as being more phonologically voiced, that is, if they responded /b/ more times than the L group, then the boundary between /b/ and /p/ for the H group on the VOT continuum would be moved towards the right with respect to the L group.
In order to determine whether there is a difference in the perception of initial English stops across proficiency levels, a 1-factor ANOVA, with proficiency group (L, H) as the between-subjects factor, was conducted. The proportion of PAFRI identification in the English mode throughout the full continuum was the dependent variable.

The distribution of PAFRI identification in the English mode as a function of voice onset time is shown in Figure 5.3. The mean response for PAFRI identification in the English mode for the L and H groups did not overlap. In fact, the lower-proficiency group perceived a stop as being /p/ at a lower VOT than the higher-proficiency group. The statistical results showed that the main effect of proficiency was significant \( F(1, 334) = 5.25, p < 0.05 \). Therefore, a significant difference between levels of proficiency was detected regarding the perception of initial L2 stops, suggesting that the lower-proficiency group does not require VOT to be as high in order to perceive the sound as /p/ in the way that the higher-proficiency group does.
Figure 5.3. PAFRI identification by lower- and higher-proficiency groups in the English mode. L2 learners (Brazilian Portuguese learners of English), and mean proportion of PAFRI identifications by proficiency group (lower, higher) as a function of voice onset time. Error bars show standard errors of the mean.

In order to determine whether the difference between the L and H groups occurred within the ambiguous area, a 1-factor ANOVA was conducted with proficiency levels (L, H) as the between-subjects factor. The proportion of PAFRI identification in the English mode was the dependent variable. Based on the perception data, the ambiguous area was defined as the range between -10 ms and +5 ms since this is the area where the L2 responses were ambiguous and there was clearly no ceiling or floor effect. Since the previous analysis, which considered the PAFRI responses altogether, showed significant differences between the L and H groups, it was expected that this difference would be found within the ambiguous range (where the phonetic space overlaps English /b/ and Portuguese /p/).
The statistical results showed that there was a significant effect of proficiency within the ambiguous area ($F(1, 70) = 8.79, p < 0.05$). As Figure 5.4 shows, within the ambiguous range, the H group requires a higher VOT in order to perceive the sounds as /p/ than the L group does.

![Graph](image)

**Figure 5.4.** Results of PAFRI identification in the English mode within the ambiguous area (-10 ms to +5 ms). Lower- and higher-proficiency groups (Brazilian Portuguese learners of English), proportion of PAFRI identification as a function of proficiency level (lower, higher).

RQ4 addressed the following question: *Does proficiency affect the perception of L2 English stops?* It was hypothesized that proficiency would affect L2 learners’ perception of English stops. More specifically, it was expected that only the high-proficiency group would require higher VOT values than the lower-proficiency group in order to perceive the sound as a /p/. This hypothesis was then satisfied since there was a significant difference in L2 English VOT perception between the L and H groups, both when analyzing their responses along the full continuum and within the ambiguous range.
In sum, the analysis of the L2 English VOT perception of stops revealed effects of proficiency level since a significant difference in the PAFRI identification between the lower- and the higher-proficiency groups was detected. The L group perceived more /p/ sounds in the ambiguous VOT range (-10 ms to +5 ms) than the H group. Therefore, in order to address RQ5 and RQ6, the two separate levels of proficiency were taken into consideration: the lower-proficiency group (12 participants) and the higher-proficiency group (12 participants).

5.3.2 Portuguese VOT Perception by L2 Learners of English and Monolingual BP Speakers

RQ5. Is L1 Portuguese perception of stops affected by L2 learning?

Comparisons between the Portuguese data from L2 learners (L, H) and from monolingual Brazilian Portuguese speakers (the control group) are able to address whether L2 learners’ perception of Portuguese stops has been influenced by exposure to L2 English. The data are able to show whether L1 phonetic drift occurred in perception among L2 learners in a foreign context. In order to determine whether L2 learners demonstrated L1 phonetic drift in their perception of initial Portuguese stops, a 1-factor ANOVA was conducted, with language group (control group, L, H) as the between-subjects factor. The proportion of PAFRI identification in the Portuguese mode was the dependent variable. If the L2 learners perceive fewer instances of Portuguese /p/ than monolingual BP speakers (e.g., L2 learners would require a higher VOT in order to perceive a /p/ sound), then this would suggest that the perception of Portuguese stops by L2 learners had been affected by the learning of L2 English.

As shown in Figure 5.5, the lower-proficiency group identified fewer /p/ responses in the Portuguese mode than the higher-proficiency group, which, in turn, identified fewer /p/
responses than the control group. Along the full continuum, the control group perceives a stop as a /p/ at a lower VOT than the L and H groups.

Figure 5.5. Overall results of PAFRI identification in the Portuguese mode. Lower- and higher-proficiency groups (Brazilian Portuguese learners of English) and the control group (monolingual Brazilian Portuguese speakers), mean proportion of PAFRI identification by language group (control group, L, H).

The statistical results showed that the differences observed in Figure 5.5 and Figure 5.6 were not statistically significant. There was no significant main effect of language group ($F(2, 837) = 2.44, p > 0.05$) in the Portuguese mode. The results showed that L2 learners, both the L and H groups, and the control group were not significantly different in terms of perception of initial stops in the Portuguese mode. This result suggests that the perceptual boundary between
/p/ and /b/ had not been shifted sufficiently to the right for the L2 learners, relative to the monolinguals, to make the difference significant. In other words, the perceptual boundary between the two phonemes /p/ and /b/ in Portuguese occurred relatively at the similar positive VOT values for both the L and H groups and the control group.

**Figure 5.6.** PAFRI identification in the Portuguese mode. L2 learners (Brazilian Portuguese learners of English), and the control group (monolingual Brazilian Portuguese speakers), mean proportion of PAFRI identifications by language group (control group, L2 learners) as a function of voice onset time. Error bars show standard errors of the mean.

RQ5 addressed the following question: Is L1 Portuguese perception of stops affected by L2 learning? It was hypothesized that the perception of Portuguese from L2 learners would be affected by L2 learning. However, no significant difference in the Portuguese VOT perception of
L2 learners (both L and H) and monolingual BP speakers was found. Therefore, this hypothesis was not satisfied.

5.3.3 Portuguese and L2 English VOT Perception by L2 Learners

RQ6. Do higher-proficiency L2 learners demonstrate that they have developed language-specific perceptual strategies for VOT categories when processing sounds in their L1 or in their L2?

These data addressed the question of whether late L2 learners (L, H) who have learned English as a foreign language with limited exposure to L2 could establish language-specific perceptual strategies as a function of language modes. A 2x(2) mixed-design ANOVA with language mode (Portuguese, English) as the within-subjects factor and proficiency group (L, H) as the between-subjects factor were conducted in order to address this question. The proportion of PAFRI identification in English and Portuguese modes was the dependent variable.

As shown in Figure 5.7, overall, L2 learners chose more PAFRI responses in the Portuguese mode than in the English mode. However, the L group does not seem to require VOT to be as high in order to perceive it as /p/ in the way that the high proficiency group did.
Figure 5.7. Overall results of PAFRI identification by L2 learners (lower, higher) in English and Portuguese modes. Lower- and higher-proficiency groups (Brazilian Portuguese learners of English), proportion of PAFRI identification as a function of language mode (Portuguese, English).

The results showed that there was a significant main effect of language mode ($F(1, 334) = 23.23, p < 0.001$). The main effect of proficiency group was not significant ($F(1, 334) = 2.47, p > 0.05$). There was a significant interaction between language mode and proficiency group ($F(1, 334) = 10.97, p < 0.05$). Because of the interaction, two data subsets were formed, one for each proficiency group. 1-factor within-subjects ANOVAs, with language mode (English, Portuguese) as the within-subjects factor, were carried out, one for each proficiency level (L, H). For the L group, the corresponding ANOVA revealed that there was no effect of language mode ($F(1, 167) = 1.08, p > 0.05$). For the H group, the corresponding ANOVA revealed that there was
a significant effect of language modes ($F(1, 167) = 34.70, p < 0.001$), with the H group requiring VOT to be higher in English than in Portuguese mode in order to perceive it as a /p/.

In order to determine whether the H group would shift boundary within the ambiguous range (-10 ms to +5 ms) as a function of language mode (the area in the phonetic space where English /b/ and Portuguese /p/ overlaps), a 1-factor ANOVA was conducted with language mode (Portuguese, English) as the within-subjects factor. The proportion of PAFRI identification in English and Portuguese modes in the ambiguous range (within -10 ms and +5 ms) was the dependent variable. It was expected that the H group would perceive more /p/ in Portuguese than in English language mode, demonstrating effects of language context.

The results showed that there was a significant effect of language mode ($F(1, 35) = 22.37, p < 0.001$). These results suggested that, for the area of ambiguity, where phonetic overlaps between Portuguese and English, the H group’s perception of initial stops shifted as a function of language context. In the Portuguese language mode, when H group was induced to think they were listening to Portuguese sounds, they were more likely to select /p/ responses. However, in the English language mode, when the H group was induced to think they were listening to English sounds, they were more likely to select /b/ responses, even though they had been exposed to the same set of sounds. Therefore, the H proficiency group perceived a stop as a /p/ at a higher VOT than the L group did. These analyses suggested that language context could prompt the more advanced L2 learners to process sounds in two separate systems (L1 and L2), which suggests that they had developed language-specific perceptual strategies for VOT categories.

RQ6 addressed the following question: Do L2 learners demonstrate that they have developed language-specific perceptual strategies for VOT categories when processing sounds.
in their L1 or in their L2? It was hypothesized that only higher-proficiency learners would demonstrate that they have developed language-specific perceptual strategies for English VOT categories. This hypothesis was satisfied since the H group (but not the L group) demonstrated that they differ in their perceptual boundary between /p/ and /b/ along the full continuum and within the ambiguous range in English context and in Portuguese context.

5.4 Discussion

The perception data of the present study were elicited through a two-alternative forced-choice identification test (2AFC). L2 learners of English (L, H) and monolingual BP speakers were exposed to a continuum of 14 VOT steps from bafri to pafri in two language modes, English and Portuguese – the same stimuli used by Gonzales and Lotto (2013). The frequency and percentage of the responses for the ambiguous range (-10 ms and +5 ms), given by L2 learners of English and monolingual BP speakers in the two language modes is summarized in Table 5.1.
Table 5.1.

The frequency percentage of responses within the ambiguous range (-10 ms and +5 ms) in the two-alternative forced-choice identification test by each language group (the control group [monolingual Brazilian Portuguese speakers], the lower- and the higher-proficiency groups [Brazilian Portuguese learners of English]).

<table>
<thead>
<tr>
<th>Language Group</th>
<th>/p/ Responses</th>
<th>/b/ Responses</th>
<th>No Responses</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>L1 PORTUGUESE</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Monolinguals</td>
<td>710 (65.75%)</td>
<td>357 (33.05%)</td>
<td>13 (1.2%)</td>
</tr>
<tr>
<td>Lower-Proficiency</td>
<td>288 (53.34%)</td>
<td>238 (44.07%)</td>
<td>14 (2.59%)</td>
</tr>
<tr>
<td>Higher-Proficiency</td>
<td>232 (42.97%)</td>
<td>304 (56.29%)</td>
<td>4 (0.74%)</td>
</tr>
<tr>
<td><strong>L2 ENGLISH</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lower-Proficiency</td>
<td>271 (50.19%)</td>
<td>253 (46.85%)</td>
<td>16 (2.96%)</td>
</tr>
<tr>
<td>Higher-Proficiency</td>
<td>155 (28.71%)</td>
<td>360 (66.67%)</td>
<td>25 (4.62%)</td>
</tr>
</tbody>
</table>

Note. The total number of responses in each condition for each language group was 540.
In the analyses of the perception data, three research questions were addressed: (RQ4) *Does proficiency affect the perception of L2 English stops?*; (RQ5) *Is L1 Portuguese perception of stops affected by L2 learning?*; (RQ6) *Do L2 learners demonstrate that they have developed language-specific perceptual strategies for VOT categories when processing sounds in their L1 or in their L2?*

In sum, the analyses demonstrated effects of proficiency between the lower- and the higher-proficiency groups, showing there was a significant difference in the perception of initial L2 English stops between these two groups in the following direction: In comparison with the H group, the L group did not require VOT to be as high in order to perceive a stop as a /p/. This difference was also found within the ambiguous area (-10 ms to +5 ms) (RQ4). Subsequent analyses revealed that the L2 learners (both L and H) did not demonstrate L1 phonetic drift (effects of the acquisition of an L2 on L1) in the perception of initial Portuguese stops (i.e., no significant difference was found between L2 learners and the monolingual BP speakers) (RQ5). When the H group was induced to process the sounds as if they were English sounds, they gave more /b/ responses than when they were induced to process the same set of sounds as if they were Portuguese sounds. This result shows that the H group (but not the L group) perceives a stop as /p/ at a higher VOT in the English mode than in the Portuguese mode, suggesting that the H group had developed language-specific perceptual strategies for stops (RQ6). Table 5.2 summarizes the results for each research question.
Table 5.2.

Summary of the results of the perception data for each research question.\textsuperscript{13}

<table>
<thead>
<tr>
<th>Research Question</th>
<th>English Mode</th>
<th>Portuguese Mode</th>
</tr>
</thead>
<tbody>
<tr>
<td>(RQ4) Does proficiency affect the perception of L2 English stops?</td>
<td>YES.</td>
<td>The L group perceives a stop as being /p/ at a lower VOT than the H group does.</td>
</tr>
<tr>
<td>(RQ5) Is L1 Portuguese perception of stops affected by L2 learning?</td>
<td>NO.</td>
<td></td>
</tr>
<tr>
<td>(RQ6) Do L2 learners demonstrate that they have developed language-specific perceptual strategies for VOT categories when processing sounds in their L1 or in their L2?</td>
<td>YES.</td>
<td>YES. Only for the H group. Both throughout the continuum and within the ambiguous range, the H group perceives a stop as /p/ at a higher VOT in the English than in the Portuguese mode.</td>
</tr>
</tbody>
</table>

\textsuperscript{13} The shaded areas represent instances in which the research question is not applicable.
CHAPTER 6 – GENERAL DISCUSSION

6.1 Introduction

The general goal of this study was to contribute to the ongoing scientific investigation of the dynamic nature of L1-L2 interactions. This was accomplished by studying the acquisition of L2 voiced and voiceless stops. This study focuses on the development of new phonetic categories by a group of L2 learners who have been exposed to their L2 primarily in a formal setting and exclusively in a community where the L2 is not spoken, i.e., their own country. The L1 of the learners in this study is Brazilian Portuguese (BP); the L2 is English. While both English and Portuguese share the fact that they have voiced and voiceless stop phonemes as /p b k g/, the phonetics of these sounds differ across these two languages: The stops /b g/ are realized as prevoiced in Portuguese, but with short-lag VOT values in English; the stops /p k/ are realized as short-lag VOT values in Portuguese, but as long-lag VOT values in English. Learning English stops can be challenging for BP learners of English, especially for adults, who may not always be sensitive to relevant but fine-grained differences between their L1 and the target language.

Toward that goal, a production task (a delayed repetition task) and a perception test (a two-alternative forced-choice identification test), each task in both English and Portuguese, were conducted with BP learners of English in both language contexts, and with monolingual BP speakers in the Portuguese context only. In the following sections, a summary of the results from the production and perception studies is followed by a general discussion. Implications of the results for research and teaching are also addressed. This chapter ends with some considerations for future studies.
6.2 Production and Perception of Stops Across Levels of Proficiency

It was hypothesized that proficiency would affect L2 English VOT production and perception, and that higher-proficiency learners (H), but not lower-proficiency learners (L), would be able to process sounds in the English monolingual mode, suggesting effects of L2 learning. For instance, the H group would demonstrate improvement in the production and perception of L2 VOT values in relation to the L group. The data analyses showed that this hypothesis was partially satisfied. In the perception study, there was a significant difference between levels of proficiency for the perception of L2 stops. The H group perceived an English stop as /p/ at a higher VOT than the L group. In the production study, however, the L and H groups produced L2 English bilabials and velars that did not differ significantly from each other. Results from the production data contradict some previous studies that show that the higher-proficiency group (e.g., more experienced learners) produces L2 stops with greater accuracy (e.g., more target-like) than the lower-proficiency group (e.g., less experienced learners) (e.g., Flege, 1987, 1991; Liao, 2005; Kong & Yoon, 2013).

Regarding the production of L2 stops, the lack of a significant difference between levels of proficiency could mean that stabilization of L2 VOT learning may have occurred, such as a learning plateau or a slowdown in the learning process. Han (e.g., 1998, 2012) argued that stabilization could be the result of three forces: (1) A natural slowdown in the learning process; for instance, the learning conditions do not provide the input and necessary practice opportunities for L2 development. (2) Stabilization can also be the result of mental processes, such as U-shaped learning (Kellerman, 1978, 1979, 1983, 1985; Sharwood Smith & Kellerman, 1989). U-shaped learning is a common phenomenon in L2 acquisition, consisting of L2 learners demonstrating initial improvement, such as target-like production, proceeding to a regression in
early stages, and then recovering in later stages. Finally, (3) stabilization can also be the result of fossilization, when learning ceases to occur.

Although the source of stabilization of L2 English VOT production of L2 learners in this study is not clear, this is not a case of fossilization. Stabilization and fossilization are understood as different processes. According to Han (2004, 2011, 2013), while stabilization involves a natural slowdown in learning and a covert restructuring of mental representation, fossilization is, by definition, permanent and cannot be reversed. In order for fossilization to be validated, the absence of learning progress would have to occur “in spite of conditions conducive to learning, such as adequate motivation to learn, abundant exposure to the target language, and plentiful opportunity for communication practice” (Han, 2013, p. 137). Since the participants in this study are L2 learners in a foreign environment, with limited exposure to L2, fossilization cannot be validated. For instance, it is possible that, given the right conditions, such as sufficient quantity and quality of L2 input, and plenty of opportunities for interactions with native speakers, L2 learners would be able to advance and continue developing their L2 production of English stops. In any case, fossilization is not expected for the participants in this study since they have not yet reached the point of having so much natural L2 input that any additional input would be a tiny proportion of the total.

The lack of differences in L2 production between different levels of proficiency may suggest an asymmetrical difference between the acquisition of VOT in a naturalistic environment and in a foreign language learning setting. Muñoz (2010) argued that findings from naturalistic learning contexts have been “somehow hastily generalized to formal learning contexts” (p. 39). The results from the present study may partially corroborate the assumption that there are
potential asymmetries between naturalistic and classroom-learning contexts in terms of L2 VOT production since effects of level of proficiency were observed for the production of L2 stops.

However, stabilization has not occurred with L2 perception of stops. The H group perceived a stop as being an English /p/ at higher VOT values than the L group did, suggesting that this group had a more target-like performance than the L group. This difference was also found in the ambiguous area (-10 ms and +5 ms), where English and Portuguese stops overlap in the phonetic space. It is interesting to note that, even though the H group would perceive L2 English stops in a more native-like fashion than the L group, the H group still could not produce L2 English stops that would differ from the L group. Although the relationship of perception and production was not the focus of the present study, this result seems to suggest that, at least at first, perception of L2 stops, as revealed by voice onset time, occurs before the production of L2 stops. According to the SLM (e.g., Flege, 1995), accurate perception of L2 sounds is necessary in order for L2 learners to be able to produce L2 sounds accurately. For Flege (1995), “the production of a sound eventually corresponds to the properties represented in its phonetic category representation” (p. 239). If accuracy with the production of L2 stops is limited by the accuracy of the perception of L2, one could expect that the H group would produce L2 stops more accurately than the L group. This, however, did not occur in this study. On the other hand, it might be that a more native-like perception of L2 stops could not be a sufficient condition for a more native-like production of L2 stops for this population. Nevertheless, for the purpose of the production study, the L and H group were pooled together as one group in order to address the study’s respective research questions. For the purpose of perception study, however, the L and H groups were kept as two separate groups in order to address its respective research questions.
6.3 Production of Stops

The analysis of the production data were able to show that BP speakers who were learners of English as L2 had formed a separate category for /p/, /b/, and /g/. L2 learners produced longer VOT values for L2 English /p/, and shorter VOT values for L2 English /b/ and /g/, than for their L1 Portuguese counterparts, showing that L2 learners were moving toward more English-like stops in L2. However, no phonetic category for /k/ was established. Therefore, L2 learners who had learned their L2 in foreign and formal contexts and who had been exposed to limited L2 input, were able to establish new VOT categories for the production of at least three L2 English stops /p/, /b/, /g/ in the expected direction.

L2 learners were not successful in establishing a new VOT category for the production of /k/. Their VOT production for L2 English /k/ and L1 Portuguese /k/ was not found to be different from each other, with the mean of 64.56 ms and 63.05 ms, respectively. (See Table 4.3, Chapter 4, for the mean VOT production of the participants in this study). It is possible that the point of departure (the natural VOT for Portuguese) was already long, and L2 learners might have felt no need to make it even longer for English. The mean VOT for English velars among English native speakers has been reported to be around 80 ms, ranging from 50 ms to 135 ms (Lisker & Abramson, 1964). In the present study, monolingual BP speakers produced Portuguese /k/ with a mean VOT value of 55.27 ms, ranging from 30.01 ms to 148.06 ms. Therefore, it is possible that L2 learners have perceived Portuguese /k/ as being an instance of English /k/ since Portuguese /k/ can be expected to be situated along the range of English /k/. If that is the case, L2 learners might have felt that no change was necessary for the production of L2 English /k/, and, as a consequence, no effort in creating a new category would have occurred. Following the Speech Learning Model (SLM)’s proposal (e.g., Flege, 1995), the perception of a significant difference
between L2 English /k/ and L1 Portuguese /k/ would be a necessary step for the formation of a new VOT category.

These findings corroborate previous studies that show that a new VOT category for /k/ seems to be more difficult to be established than for other stops. López and Counselman (2013), for instance, investigated the L2 production of Spanish stops by English speakers in a foreign context. Although these L2 learners had established new VOT categories for the production of L2 Spanish /p/ and /t/, the production of /k/ in L2 Spanish and English was not significantly different. The authors argued that the range of English and Spanish VOT for /k/ overlaps, and, consequently, that L2 learners might not have perceived these sounds as being different sounds, blocking the formation of a new phonetic category. Therefore, the findings in the present study involve those of a similar study with a comparable population.

The SLM (e.g., Flege, 1995) helps us understand the complexities of L1-L2 interactions involved here. According to the SLM, sounds that are perceived to be linked (diaphones) are produced in a similar manner. If learners discern at least some of the phonetic differences between L1 and L2 sounds, new phonetic categories will be established. However, the new category formation for an L2 sound may be blocked by the mechanism of equivalence classification, leading learners to perceive the L2 sounds and the L1 counterparts as related. Learners will eventually produce the L2 sounds with influences of L1. According to Flege (1995), the mechanism of equivalence classification, which helps children acquire their L1 (e.g., children are able to detect equivalent sounds, despite differences in speakers and contexts), can pose a challenge for L2 learners. Acoustic and articulatory differences may not prevent learners from accurately perceiving L2 sounds.
The establishment of a new category is linked to perception: “the greater the perceived distance of an L2 vowel from the closest L1 vowel, the greater is the likelihood that a new category will be established for the L2 vowel” (Flege, 1995, p. 243). The SLM also proposes that the capacities related to the establishment of new phonemic categories, which are available for children acquiring their first language, remain intact throughout the life span, that is, they “remain accessible for use in L2 learning” (Flege, 2002, p. 7). Phonetic category dissimilation may (or may not) be the result of having learning a phonetic category. Therefore, within the SLM approach, the absence of formation of a new VOT category for L2 English /k/ in this study could be understood as the result of phonetic category assimilation: Portuguese /k/ and English /k/ were perceived as “similar” sounds, which led L2 learners to produce them in a similar manner. On the other hand, the formation of a new VOT category for L2 English /p/, /b/, and /g/ could be explained through the phonetic category dissimilation: Learners were able to perceive Portuguese and English /p/, /b/, and /g/ as different sounds, which led them to strive to produce them as distinctive sounds.

Results from comparisons between the production of Portuguese stops produced by L2 learners of English and by monolingual BP speakers helped the understanding of the acquisition of L2 VOT. L1 Phonetic drift was found in the production of three Portuguese stops, /b/, /k/, and /g/ in the following direction: Portuguese /b/ and /g/, produced by L2 learners, had longer negative VOT values than those produced by monolingual speakers; that is, their production of Portuguese /b/ and /g/ was moving away from L1 and L2 norms. Their Portuguese /k/ was produced with longer positive VOT values than monolinguals; that is, they were producing a Portuguese /k/ that were more English-like.
Although Portuguese /k/ produced by L2 learners had significantly longer VOT values than the Portuguese /k/ produced by monolinguals, L2 learners did not establish a new L2 VOT category for this stop. The presence of L1 phonetic drift for the stop /k/ suggests that L2 learners’ production of Portuguese /k/ had become more English-like, moving toward L2 norms. Therefore, Portuguese /k/ was influenced by L2, revealing the occurrence of assimilatory drift (Chang, 2011).^{14}

Since no difference in production of L2 stops between the H and L groups was found in the present study, the effects of L2 on L1 for the Portuguese stops /b/, /k/, and /g/ occurred for learners with more proficiency (more years of English classes), and learners with less proficiency (beginners). Chang (2011) showed that L1 phonetic drift for stops can occur in the production of novice learners, who had just had weeks of L2 exposure, showing that L1 phonetic drift in L1 may not be attributed only to the results of extensive exposure to L2. The same assumption may be extended to the present study for the production of L2 stops since the participants had acquired L2 English in a formal context, with limited exposure to L2 input. In addition, the L1 phonetic drift in this study may not be explained as the result of a lack of L1 use since the participants were living in their home country, Brazil, at the time the data were collected. It is safe to conclude that, in general, L1 phonetic drift for the production of VOT categories does not seem to require longer experience with L2 (e.g., many years of English classes) in order to occur, nor does it seem to require extensive exposure to L2. (Note, however, that L1 phonetic drift occurred only for the production of Portuguese stops, not for the perception of Portuguese stops – discussion about the perception of stops follows in the next section.)

---

^{14} Assimilatory drift (L1 moves toward L2 norms) and dissimilatory drift (L1 moves away from both L1 and L2 norms) were discussed by Chang (2011) in reference to changes in L1 due to exposure to L2.
According to SLM, L2 speakers “strive to maintain phonetic contrast between all of the elements in their L1/L2 phonetic space” (Flege, Schirru, & Mackay, 2003, p. 470), so they can best distinguish between sounds that are perceived to be similar in L1 and L2, helping L2 learners maintain these sounds sufficiently dissimilar. In the case of the production of English /b/ and /g/, not only was the L2 English production moving in the direction of English (more English-like; that is, shorter negative VOT values than their L1 Portuguese /b/ and /g/), but also their L1 Portuguese production of /b/ and /g/ was moving away from the L1 norms. By adding voicing, L2 learners produced more “exaggerated” Portuguese sounds, resulting in dissimilatory drift (Chang, 2011). Dissimilatory drift could be a way to augment the perceptual distinction between /b/ and /g/ in L1 and L2. Emphasizing the voicing feature in L1 Portuguese (dissimilatory drift) and producing L2 English /b/ and /g/ more English-like (phonetic category dissimilation) might have been L2 learners’ strategies to keep the phonetic features of these sounds (voice and voiceless) more salient.

It is interesting to note that, by enhancing the voice feature in their L1 Portuguese, L2 learners of English ended up producing allophones of Portuguese /b/ and /g/. L2 learners seem to widen the phonemic contrast between phonologically voiced and voiceless Portuguese stops. It can be argued that enhancing an allophonic cue may have helped L2 learners to distinguish sounds that could otherwise be ambiguous. Making /b/ and /g/ in L1 and L2 as dissimilar as possible might have helped L2 learners cope with the challenge of acquiring new VOT categories for these sounds. Taken as a whole, it is not an easy task: L2 learners have to devoice the sounds and add a new feature by producing them within short-lag VOT range.

Regarding the production of /p/, L2 learners of English succeeded in establishing a new phonetic category. L2 learners produced longer VOT values for L2 English /p/ than for
Portuguese /p/, showing that their L2 production was moving toward a more typical English /p/. On the other hand, no L1 phonetic drift was found for Portuguese /p/. L2 learners were able to boost the phonetic difference between L1 /p/ and L2 /p/ without showing interference of L2 on L1. This result may suggest that, overall, the acquisition of L2 /p/ could be less challenging for these L2 learners than the other stops. Their relative success with the production of /p/ (formation of a new phonetic category without L1 phonetic drift, but still different from native English speakers) might be related to the fact that L2 learners do not need to devoice the sound, as they are expected to do with English /b/, but have to add aspiration. The aspiration feature might be more perceptually salient for L2 learners, which might have helped them in the acquisition process and might have helped them have their Portuguese /p/ restrained from being affected by L2 learning. Universal properties of stops might also have had some influence. Kewly-Port and Preston (1974) investigated the acquisition of English stops by children, and found that children were able to produce short-lag VOT values (English /d/) similar to adults, whereas their long-lag VOT values (English /t/) were less similar to adults. Other studies have shown similar results (e.g., Jakobson, 1968, who first observed this; Macken & Barton, 1979, 1980). Their findings suggest that short-lag VOT could be universally unmarked. If that is true, it is possible that L2 learners would find it relatively easier and more natural to suppress and control the influences of L2 /p/ on Portuguese /p/ (short-lag), but not so much for the other stops that could be more marked than /p/.

In sum, the findings in this study support the SLM claim that L1 and L2 phonetic systems “exist in a common phonological space” (Flege, 2007, p. 366). L1-L2 phonetic systems have been shown to interact and influence each other as these two systems go through the processes of

---

15 Aspiration is here defined as described by Lisker and Abramson (1964): “The noise feature of aspiration is […] a large delay in voice onset” (p. 387).
self-organization, through either a possibly phonetic category assimilation (L2 English /k/), or a phonetic category dissimilation (L2 English /p/, /b/ and /g/). This study also shows that L1 phonetic drift can be part of the learning process of L2 VOT. For instance, L1 phonetic drift may occur in L1, even when no phonetic category is created in L2 (/k/). L1 phonetic drift may also be a way to help L2 learners maintain the phonetic distance between sounds that share the same phonological space in L1 and L2 as far apart as possible for some stops (/b/ and /g/), but not for others (/p/). Therefore, this study shows that these processes of re-organization for the production of L1-L2 stops may involve the establishment of new VOT categories (L2 English /p/, /b/ and /g/), and the presence of L1 phonetic drift, either showing that L1 is converging toward L2 (L1 Portuguese /k/), or that L1 is departing from L1 norms (L1 Portuguese /b/ and /g/). This study also shows that improvement in production of L2 VOT categories can be achieved, even in conditions of formal foreign language instruction and with limited exposure to L2 input. Both beginners and those who had more experience with L2 English demonstrated phonetic category formation in L2 (with the exception of /k/), showing they were sensitive to fine-grained differences in the VOT production in L1 and L2. However, the acquisition of L2 in a foreign environment (e.g., attending English classes) may not be enough for L2 learners to advance their L2 learning of VOT categories, which may result in learning stabilization after the initial stages.

6.4 Perception of Stops

The analyses of the perception data were able to show that only the H group could process the same set of sounds on a continuum from bafri to pafri in the respective monolingual language mode, that is, either as English sounds or as Portuguese sounds, depending on the
language context. The H group shifted their phonetic boundary as a function of language mode only. There was a difference between levels of proficiency in the perception of L2 English VOT categories, which showed that the group with more L2 experience (e.g., those who had taken more English classes) was sensitive to language context. For instance, in the Portuguese mode, the H group was more likely to perceive a stop as being a Portuguese /p/ at a lower VOT than in the English mode, even though they had been exposed to the same set of sounds. The H group demonstrated this skill throughout the full continuum and within the ambiguous range (-10 ms to +5 ms), where the phonetic space between L1 Portuguese and L2 English overlaps. The L group, however, could not shift their phonetic boundary as a function of language mode. Therefore, this study shows that those in the H group who had acquired their L2 in foreign and formal contexts with limited exposure to L2 input were able to demonstrate that they have developed language-specific perceptual strategies for VOT categories. This is a skill that, up to now, has been shown to be available only to higher-proficiency bilinguals (García-Sierra, Diehl, & Champlin, 2009; Gonzales & Lotto, 2013).

Although exposure to L2 input in the classroom in the L1 country results in improvement of L2 VOT perception, it might not be enough to promote continuous development since the H group (mean of length of learning was 9.94 years) did not differentiate from the L group (mean of length of learning was 3.02 years) in terms of production of L2 stops (as discussed in the previous section). Nevertheless, despite the challenges (e.g., almost no contact with native speakers of English), the H group was able to demonstrate language-specific perceptual strategies, showing that the more advanced learners were sensitive to L2 VOT across language contexts.
The results from the present study have demonstrated that the perception of L1 Portuguese VOT by L2 learners was affected by L2 experience. For instance, the perceptual boundary between /p/ and /b/ had not been shifted sufficiently to the right for the L2 learners (both L and H groups) to make a significant difference in relation to monolingual BP speakers. Therefore, L1 phonetic drift in L2 VOT perception was not observed. This finding suggests that L2 learners who were living in a foreign context in their L1 community (Brazil) with limited exposure to L2 input were able to prevent their L1 perception from being influenced by the learning of English.

In this study, language mode has been assumed to be relevant in order to promote high levels of processing and help L2 learners demonstrate language-specific perceptual strategies. Not only linguistic, but also nonlinguistic cues may prompt monolingual language mode (Grosjean, 1985, 1994, 1997, 1998, 2001, 2013), affecting L2 perception and production of stops, even with L2 learners who had limited L2 experience. In this study, language mode was controlled to create the best environment for L2 learners to be able to place themselves in a monolingual mode when processing the sounds as L1 or L2. Some of these controlled cues were, for instance, the phonetic cues in the stimuli (the English /ɹ/ and Portuguese /ɾ/ in the words bafri and pafri); the location of the experiment (e.g., the experiments in English were conducted in English schools); the language background of the researcher and the research assistant (a native speaker of English conducted the English experiments and a native speaker of Portuguese conducted the Portuguese experiments); learners’ expectations (L2 learners were expecting to hear either L1 sounds or L2 sounds); the colors projected on the computer screen (colors of the Brazilian flag in the Portuguese experiments and colors of the American flag in the English experiments); the words English or the word Português projected on the computer screen in the
English and Portuguese experiments, respectively; and so forth. It was expected that these cues would help L2 learners to position themselves either in the respective language mode on the monolingual-bilingual mode continuum by providing constant reminders of the language in focus.

In sum, the study shows that the categorization (p/b) by the H group was context-dependent, that is, categorization occurs as a function of language mode. In addition, the H group demonstrated that they possess perceptual knowledge (not necessarily conscious), and that they were able to use this knowledge during the perceptual speech experiment. This study supports the argument that speech perception of L2 learners correlates with language context and listeners’ expectations, at least for more advanced learners. Moreover, L2 learners who live in an L1 environment and use L1 daily have demonstrated the ability to prevent their L1 perception from deviating from that of monolingual speakers.

6.5 Implications for Teaching

Results from this study may have a number of implications for teaching practice. Specific learners’ needs unveiled in research conducted in foreign and formal contexts could be of paramount importance since the effectiveness of L2 language teaching is, many times, the only resource for these learners. For instance, this study showed that L2 learners seemed to experience learning stabilization for the production of L2 VOT categories. In this case, pedagogical intervention may be necessary in order to help learners progress on their learning route. For instance, L2 learners might need to be exposed to greater amounts of opportunities for L2 use in the classroom (e.g., Piske, 2007) as well as greater quality and quantity of L2 input (e.g., Flege &
Liu, 2001) in order for them to obtain a suitable learning environment for continuous L2 development.

Furthermore, this study suggests that the acquisition of L2 VOT categories in a foreign context might have additional challenges that are not as prevalent in a naturalistic setting. For instance, this study shows that the production of L1 stops by monolinguals and by L2 learners displays differences. Therefore, it is possible that English native speakers who live and/or teach English in foreign countries would perceive and/or produce English stops in ways that would deviate from monolingual English speakers that live in their L1 community. In fact, native speakers of the target language who have spent most of their time in a foreign country with non-native speakers and who have been exposed to foreign accents and ungrammatical L2 input may develop L2 norms that differ from other monolingual speakers (e.g., Flege, Frieda, & Nozawa, 1997). Therefore, there is the possibility that L2 learners in their L1 country are exposed to L2 input that differs from monolingual speakers in their English-speaking community.

Other challenges for L2 learners in a foreign context have been revealed in previous studies. For instance, explicit instruction focusing on L2 phonology and pronunciation may not occur in the classroom. Research has shown that pronunciation “receives little attention in most foreign language classrooms” (Piske, MacKay, & Flege, 2001, p. 200). In addition, the quality of the input that the L2 learner receives in the classroom might not be ideal. For instance, L2 learners might hear incorrect pronunciation from their teachers (Piske, 2007).

There is some evidence that production and perception of L2 VOT can be improved through specific training (Aliaga-García, 2007; Flege, 1989; Kissling, 2013; Lord, 2005). As stated by Piske et al. (2001), examining the influence of formal instruction on the degree of L2 foreign accent has not produced encouraging results for language teachers. As the present study
shows, years spent in a school in their L1 country might not be enough for L2 learners to maintain their L2 development. Appropriate phonetic training in L2 stops might help L2 learners. Most likely, additional methodological implementations might be necessary, such as encouraging L2 learners to speak as much L2 as possible in a learning environment with extensive high-quality input (Aliaga-García, 2007) and provide specific perceptual training.

6.6 Considerations for Future Studies

Future studies might be interested in investigating whether the findings in the present study could be extended to the experience of L2 learners in their everyday lives. For instance, it is not clear whether L2 learners’ ability demonstrated in the perception experiments could mean that L2 learners were able to distinguish words with initial p/b or the extent to which English monolingual speakers would judge the L2 production of stops intelligible. In Portuguese production, the distinction between phonologically voiced and voiceless stops may entail other acoustic cues besides VOT, such as the duration of the adjacent vowel, the burst amplitude, and the closure duration (Melo, Mota, Mezzomo, Brasil, Lovatto, & Arzeno, 2014). It is not clear, however, the extent to which these acoustic cues would be relevant for perception. Future studies could help determine the relevance of these acoustic cues in Portuguese perception of stops by native speakers of Portuguese, as well whether these phonetic cues could play a relevant role in the perception of Portuguese as a foreign/second language.
“Why do Brazilians say ‘I am from São Baulo’?”, a professor from an American university asked me. The interplay between production (the Brazilian student produced a Portuguese /p/) and perception (the professor heard an English /b/) in L1 and L2 can be complex and challenging for L2 learners, especially when they involve relevant but fine-grained differences between L1 and L2. The general goal of the present study is to investigate the perception and production of L2 English and L1 Portuguese stops in initial position by Brazilian Portuguese (BP) learners of English and monolingual BP speakers. All participants in the study had learned English in a formal context with limited exposure to L2 input in their L1 country. This dissertation included four studies: two delayed repetition tasks, one in L1 and one in L2, conducted to elicit the production data; and two two-alternative forced-choice (2AFC) tests, one in L1 and one in L2, conducted to elicit the perception data. In the delayed repetition tasks, participants produced English and Portuguese words with initial /p b k g/ stops. In the 2AFC tests, participants were exposed to the same set of sounds (a continuum from /b/ to /p/), but were induced to process the sounds as English in the English sessions, and as Portuguese in the Portuguese sessions. The acoustic correlation examined was the voice onset time (VOT).

There were three research questions for the production study and three research questions for the perception study. They were: (RQ1) Does proficiency effect the production of L2 English stops?; (RQ2) Is L1 Portuguese production of stops affected by L2 learning?; (RQ3) Do L2 learners maintain separate distributions for the production of L2 English and L1 Portuguese stops? (RQ4) Does proficiency affect the perception of L2 English stops?; (RQ5) Is L1 Portuguese perception of stops affected by L2 learning?; (RQ6) Do L2 learners demonstrate that
they have developed language-specific perceptual strategies for VOT categories when processing sounds in their L1 or in their L2?

Effects of proficiency level were found only for the perception of L2 stops (RQ4), not for the production of L2 stops (RQ1). The analyses of the perception data showed that the boundary between /p/ and /b/ for the H group in the VOT continuum was moved toward the right in respect to the L group. The H group required VOT to be higher than the L group in order to perceive a stop as /p/. These differences in the L2 perception between levels of proficiency were also observed within the ambiguous area (-10 ms to +5 ms).

L1 phonetic drift (effects of L2 on L1) was found only for the production of L1 Portuguese stops (RQ2), but not for the perception of L1 Portuguese stops (RQ5). The analysis of the Portuguese production of stops by L2 learners indicated that their L1 Portuguese /b/, /k/, and /g/, but not /p/, departed from the stops produced by monolingual BP speakers in the following direction: L2 learners produced longer negative VOT values for Portuguese /b/ and /g/ (moving away from L1 and L2 norms), and longer positive Portuguese VOT values for /k/ (more English-like) than did monolingual BP speakers. Such findings strongly support the assumption that our L1-L2 perceptual systems remain flexible throughout the course of our lives, and that they can change in response to language context. Additionally, they show that the phonetic systems of the L1 and the L2 are interconnected.

The analyses of the production data also showed that L2 learners were able to maintain separate categories for L2 English and L1 Portuguese for the stops /p/, /b/ and /g/, but not for /k/ (RQ3). When compared to their Portuguese production, L2 learners produced /b/ and /g/ with shorter negative VOT values in L2 English and longer VOT values for L2 English /p/ (more target-like).
The analyses of the perception data showed that the H group, but not the L group, was able to shift perceptual boundary as a function of language mode (RQ6). In the English session, L2 learners gave more /b/ responses than in the Portuguese session. This result showed that the H group perceived a stop /p/ at a higher VOT in the English mode than in the Portuguese mode, indicating that the H group had developed language-specific perceptual strategies for stops. This result was also consistent when considering only L2 learners’ responses within the ambiguous area (-10 ms to +5 ms). The H group was able to demonstrate development of language-specific perceptual strategies since its members had learned new perceptual categories to be used specifically in their L2. Therefore, this study indicates that results from Gonzales and Lotto (2013)’s study may be generalized to include late L2 learners who have learned their L2 in a formal setting with limited L2 input in the context of the L1 country, but only for those who are more advanced in their L2 learning.
APPENDIX A

English language proficiency test

Proficiency Test for English Learners in Brazil

Subject n. _________

This test is based on the St. George International online English test, available online.

Please choose the correct answer.

1. What’s _________ name?
   ☐ you    ☐ she    ☐ your    ☐ yours

2. We’re Chinese. We’re _________ Beijing.
   ☐ for    ☐ from    ☐ in    ☐ at

3. Jane’s _________ nice and polite.
   ☐ a    ☐ from    ☐ very    ☐ at

4. _________ a light?
   ☐ Do have you    ☐ Do you got    ☐ Have you got    ☐ Are you have

5. Margaret _________ usually come by bus.
   ☐ doesn’t    ☐ isn’t    ☐ don’t    ☐ aren’t

6. They _________ at home last night.
   ☐ aren’t    ☐ weren’t    ☐ don’t    ☐ didn’t

7. What _________ you say?
   ☐ are    ☐ have    ☐ were    ☐ did
8. Why ________ crying?
   ○ are you  ○ you are  ○ do you  ○ you do

9. Where ________ to spend your holidays next summer?
   ○ you are going  ○ are you going  ○ you will  ○ will you

10. ________ never been to the theatre before.
    ○ I’ll  ○ I’m  ○ I can  ○ I’ve

    ○ are made  ○ made  ○ make  ○ are making

12. Where ________ when you met him?
    ○ does he live  ○ was he live  ○ was he living  ○ is he living

13. If ________ I’ll tell him you called.
    ○ I’ll see him  ○ I see him  ○ I’d see him  ○ I saw him

14. What ________ since you arrived.
    ○ are you doing  ○ will you do  ○ would you do  ○ have you been doing

15. Wine ________ made in Italy for thousands of years.
    ○ have been  ○ is being  ○ has been  ○ are being

    ○ use to  ○ was use to  ○ used to  ○ was used to

17. If I ________ , I would go out more.
    ○ wasn’t married  ○ didn’t marry  ○ wouldn’t marry  ○ haven’t married
18. I was very _________ in the story.
   ○ interest  ○ interesting  ○ interested  ○ interests

19. You _________ come if you don’t want to.
   ○ don’t need  ○ don’t need to  ○ didn’t need to  ○ didn’t need

20. I _________ see you tomorrow.
   ○ did  ○ will  ○ have  ○ does

21. ___________ is bad for you.
   ○ Smoking  ○ The smoking  ○ To smoke  ○ Smoker

22. I _________ told him if I had known he was your brother.
   ○ hadn’t  ○ wouldn’t  ○ wouldn’t have  ○ don’t have

23. He _________ living there for three years before they found him.
   ○ had been  ○ has been  ○ might be  ○ could be

24. I wish you _________ all the time.
   ○ don’t shout  ○ won’t shout  ○ wouldn’t shout  ○ haven’t shout

25. By the time you arrive, ___________.
   ○ he’ll leave  ○ he’ll have left  ○ he leaves  ○ he left

26. The house _________ built in the 16th century.
   ○ might have been  ○ might be  ○ might have be  ○ might have

27. Don’t forget _________ me a newspaper.
   ○ buying  ○ that you buy  ○ to bought  ○ to buy
28. Whenever there was a visitor, the dog ___________ to the door.
   ○ will run   ○ is running   ○ would run   ○ was running
   __________________________________________________________

29. He is an executive in ___________ .
   ○ the car industry   ○ car industry   ○ car industries   ○ car industrial
   __________________________________________________________

30. Peter sold his car ___________ save money.
   ○ as a result   ○ so he   ○ in order to   ○ because to
   __________________________________________________________

31. He advised me ___________ the doctor.
   ○ that I see   ○ to see   ○ seeing   ○ see
   __________________________________________________________

32. I ___________ travelling by bus.
   ○ am not used to   ○ didn’t used to   ○ used to   ○ do not used to
   __________________________________________________________

33. He didn’t come last night. I wish that he__________.
   ○ had   ○ did   ○ have   ○ has
   __________________________________________________________

34. I am going to a wedding. I need to ___________.
   ○ be cutting my hair   ○ cutting my hair   ○ have my hair cut   ○ get cut my hair
   __________________________________________________________

35. Which would you ___________ have: gold or silver?
   ○ prefer   ○ could   ○ rather   ○ better
   __________________________________________________________

36. My sister has been in the hospital. I wonder how she ___________.
   ○ is getting on   ○ gets on   ○ has got across   ○ is getting away
   __________________________________________________________

37. The man said he did not ___________ to go by bus.
   ○ care for   ○ bother about   ○ mind having   ○ much mind
   __________________________________________________________
38. Although he confessed to the crime, the judge let the boy_________.
○ alone ○ come in ○ off ○ forgive

39. I’ve never __________ that word before.
○ gave away ○ come across ○ come over ○ come into

40. The student could not answer the question, so he_________.
○ gave off ○ gave into ○ gave up ○ gave away
APPENDIX B

L2 English proficiency levels, according to the Council of Europe’s Common European Framework, used by the St. George International English Proficiency Test.

Source: St. George International – The Language Specialists website.  
http://www.stgeorges.co.uk/online-english/online-english-test
APPENDIX C

Placement of the L2 learners according to their scores in the English language proficiency test (1, lower-proficiency group; 2, higher-proficiency group).
<table>
<thead>
<tr>
<th>Subject</th>
<th>Score</th>
<th>Proficiency</th>
</tr>
</thead>
<tbody>
<tr>
<td>2</td>
<td>14</td>
<td>1</td>
</tr>
<tr>
<td>3</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>7</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>8</td>
<td>17</td>
<td>1</td>
</tr>
<tr>
<td>13</td>
<td>24</td>
<td>1</td>
</tr>
<tr>
<td>14</td>
<td>18</td>
<td>1</td>
</tr>
<tr>
<td>17</td>
<td>21</td>
<td>1</td>
</tr>
<tr>
<td>20</td>
<td>10</td>
<td>1</td>
</tr>
<tr>
<td>22</td>
<td>20</td>
<td>1</td>
</tr>
<tr>
<td>23</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>24</td>
<td>26</td>
<td>1</td>
</tr>
<tr>
<td>30</td>
<td>22</td>
<td>1</td>
</tr>
<tr>
<td>31</td>
<td>26</td>
<td>1</td>
</tr>
<tr>
<td>33</td>
<td>16</td>
<td>1</td>
</tr>
<tr>
<td>35</td>
<td>27</td>
<td>1</td>
</tr>
<tr>
<td>36</td>
<td>15</td>
<td>1</td>
</tr>
<tr>
<td>37</td>
<td>19</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>36</td>
<td>2</td>
</tr>
<tr>
<td>5</td>
<td>40</td>
<td>2</td>
</tr>
<tr>
<td>9</td>
<td>31</td>
<td>2</td>
</tr>
<tr>
<td>10</td>
<td>38</td>
<td>2</td>
</tr>
<tr>
<td>11</td>
<td>38</td>
<td>2</td>
</tr>
<tr>
<td>12</td>
<td>38</td>
<td>2</td>
</tr>
<tr>
<td>15</td>
<td>36</td>
<td>2</td>
</tr>
<tr>
<td>16</td>
<td>31</td>
<td>2</td>
</tr>
<tr>
<td>19</td>
<td>39</td>
<td>2</td>
</tr>
<tr>
<td>21</td>
<td>37</td>
<td>2</td>
</tr>
<tr>
<td>25</td>
<td>32</td>
<td>2</td>
</tr>
<tr>
<td>26</td>
<td>31</td>
<td>2</td>
</tr>
<tr>
<td>27</td>
<td>37</td>
<td>2</td>
</tr>
<tr>
<td>28</td>
<td>35</td>
<td>2</td>
</tr>
<tr>
<td>29</td>
<td>35</td>
<td>2</td>
</tr>
<tr>
<td>32</td>
<td>28</td>
<td>2</td>
</tr>
<tr>
<td>34</td>
<td>31</td>
<td>2</td>
</tr>
<tr>
<td>38</td>
<td>29</td>
<td>2</td>
</tr>
</tbody>
</table>
APPENDIX D

LANGUAGE BACKGROUND QUESTIONNAIRE
(para brasileiros falantes/estudantes de inglês)

O questionário abaixo procura explorar a sua história linguística, e suas impressões pessoais sobre o aprendizado de inglês. Fornecer respostas completas e corretas às perguntas é fundamental para o sucesso da minha pesquisa.

MUITO OBRIGADA pelo seu tempo em responder o questionário.

<table>
<thead>
<tr>
<th>Nome: __________________________________________</th>
<th>Participante n. __________</th>
</tr>
</thead>
<tbody>
<tr>
<td>Telefone: _________________________</td>
<td>email: ___________________</td>
</tr>
<tr>
<td>Data: ________________________</td>
<td></td>
</tr>
</tbody>
</table>

1. Você tem problemas de audição?   SIM    NÃO
2. Você tem visão normal ou corrigida? YES NO
3. Sexo:  M – F
4. Idade: ______________
5. Educação:
   ( ) Segundo grau – completo / incompleto
   ( ) Terceiro grau/universidade – completo / incompleto
   ( ) Pós-graduação – completo / incompleto
6. Local de nascimento (cidade/estado): __________________________________________
7. Local onde você mora (cidade/estado) __________________________________________
8. Há quanto tempo você mora neste local? ________________________________________
9. Minha língua materna é _____________________________________________________
10. Você já estudou outra língua sem ser inglês e português?   SIM    NÃO
    Se a resposta for SIM, que língua(s) estudou? __________________________________
    Por quanto tempo? ____________________________________________________________
11. Idade que você começou a estudar inglês: _______________________
12. Há quanto tempo você estuda inglês em uma escola de língua? ____________________
13. Há quanto tempo você estuda inglês em uma escola pública? ____________________
14. Você já foi a um país que fala inglês?  SIM    NÃO
Se a resposta for SIM, qual foi(ram) o(s) país(es)? _____________________________
Por quanto tempo? __________________________________________________________

15. Você já estudou ou viveu em um país que fala inglês?   SIM     NÃO
Se a resposta for SIM, qual foi o país? _____________________________
Por quanto tempo? __________________________________________________________

16. No Brasil, você já teve um(a) professor(a) de inglês que era nativo da língua?
SIM     NÃO
Se a resposta for SIM, por quanto tempo? ______________________________________

17. No Brasil, você já teve algum contato com nativos da língua inglesa (fora da escolar de línguas)?   SIM     NÃO
Se a resposta for SIM, por favor explique.

Por quanto tempo você teve contato com eles (days, months, years)?

18. Com que frequência você tem contato com falantes nativos da língua inglesa?
Explique.

AUTOEXAME DE SUAS HABILIDADES EM INGLÊS

Por favor, faça uma estimativa de suas habilidade em inglês escolhendo entre 1 (muito baixa) a 7 (excelente) para cada linha abaixo:

<table>
<thead>
<tr>
<th></th>
<th>1 (muito baixa)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7 (excelente)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Falar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Escrever</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Ouvir</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Gramática</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulário</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pronúncia</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Leitura</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
AUTOPERCEPÇÃO DO USO DO INGLÊS

Por favor, faça uma estimativa em porcentagem do quanto você usa inglês atualmente nas seguintes situações ou lugares.

Ex. Se, na escola de línguas, você usa inglês aproximadamente 80% do tempo, você escolhe “80%”.

<table>
<thead>
<tr>
<th></th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Na escola de línguas</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Em casa (e.g., tarefas)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Na Internet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>No trabalho</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vendo filmes, vídeos, Youtube, etc.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Com amigos</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aulas online</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Outro(s):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

AUTOPERCEPÇÃO DA MOTIVAÇÃO

Por favor, circule um número de 1 (discordo totalmente) a 7 (concordo totalmente) que melhor responda à pergunta.

1. Eu estou estudando inglês porque vai me ajudar a conseguir um trabalho melhor.
   (discordo totalmente) 1-----------2---------3----------4---------5----------6--------7 (concordo totalmente)

2. Eu estou estudando inglês porque eu adoro a cultura inglesa/americana.
   (discordo totalmente) 1-----------2---------3----------4---------5----------6--------7 (concordo totalmente)

3. Estudar inglês me faz sentir importante.
   (discordo totalmente) 1-----------2---------3----------4---------5----------6--------7 (concordo totalmente)
4. Eu não quero parar de estudar inglês. 
   (discordo 1---------2---------3---------4---------5---------6---------7) (concorro totalmente)

5. Eu gosto de estudar inglês. 
   (discordo 1---------2---------3---------4---------5---------6---------7) (concorro totalmente)

6. Quando eu estou falando inglês, eu tento o máximo não usar português. 
   (discordo 1---------2---------3---------4---------5---------6---------7) (concorro totalmente)

7. Eu tento imitar o sotaque dos ingleses/americanos o melhor que posso. 
   (discordo 1---------2---------3---------4---------5---------6---------7) (concorro totalmente)

THANK YOU VERY MUCH!
APPENDIX E

LANGUAGE BACKGROUND QUESTIONNAIRE
(for Brazilian Portuguese learners of English)

The following survey seeks to explore your language history, and your feelings regarding the learning of English. Providing full and accurate answers to these questions is absolutely important for the success of this survey. THANK YOU for taking the time to answer this survey.

Name: __________________________________________ Participant n. ___________
Telephone: _____________________ email: _____________________________
Date: ________________________

1. Do you have normal hearing?   YES   NO
2. Do you have normal or corrected vision?   YES   NO
3. Gender:  M – F
4. Age: _______________
5. Education:
   (   ) High school – complete / incomplete
   (   ) College degree – complete / incomplete
   (   ) Graduate program – complete / incomplete
6. Birth place (city/state): _________________________________________________
7. Place where you live (city/state) __________________________________________
8. How long do you live there? _____________________________________________
9. My native language is ____________________________________________________
10. Have you studied a language, besides Portuguese and English?   YES   NO
    If YES, which one(s)? ____________________________________________________
    For how long? __________________________________________________________
11. Age you started learning English: ______________________________
12. How long have you studied English in a language school? __________________
13. How long have you studied English in a public school? ______________________
14. Have you ever visited an English speaking country?   YES   NO
If YES, which one(s)? _____________________________________________________
For how long? ________________________________________________________

15. Have you ever studied or lived in an English speaking country?  YES  NO
If YES, where? ________________________________________________________
For how long? ________________________________________________________

16. In Brazil, have you had English teachers who were native speakers of English?
YES  NO
If YES, for how long? __________________________________________________

17. In Brazil, have you ever had any interactions with native speakers of English (outside
the language school)?  YES  NO
If YES, please explain. __________________________________________________
For how long have you had contact with them (days, months, years)?

18. How often have you interacted with native English speakers? Explain.

____________________________________________________________________

YOUR SELF-PERCEPTION OF YOUR ENGLISH ABILITIES

Please estimate your English abilities by choosing from 1 (very poor) to 7 (excellent) for each
row below:

<table>
<thead>
<tr>
<th></th>
<th>1 (very poor)</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>7 (excellent)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Speaking</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Writing</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Listening</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grammar</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Vocabulary</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pronunciation</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Reading</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
YOUR SELF-PERCEPTION OF THE USE OF ENGLISH

Please estimate in percentage how much English you currently use in the following situations or places.

Ex. If, at the language school, you use English about 80% of the time you are there, you would choose “80%”.

<table>
<thead>
<tr>
<th></th>
<th>0%</th>
<th>10%</th>
<th>20%</th>
<th>30%</th>
<th>40%</th>
<th>50%</th>
<th>60%</th>
<th>70%</th>
<th>80%</th>
<th>90%</th>
<th>100%</th>
</tr>
</thead>
<tbody>
<tr>
<td>At the language school</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At home (e.g., homework)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>On the Internet</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>At work</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Watching movies, videos, Youtube, and the like.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>With friends</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Classes online</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Other(s):</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

YOUR SELF-PERCEPTION OF MOTIVATION

Please circle the number from 1 (strongly disagree) to 7 (strongly agree) that best answers the question.

1. I am studying English because it will help me to get a better job.
   (strongly disagree) 1--------2--------3--------4--------5--------6--------7(strongly agree)

2. I am studying English because I love English/American culture.
   (strongly disagree) 1--------2--------3--------4--------5--------6--------7(strongly agree)

3. Studying English makes me feel important.
   (strongly disagree) 1--------2--------3--------4--------5--------6--------7(strongly agree)

4. I don’t want to stop studying English.
   (strongly disagree) 1--------2--------3--------4--------5--------6--------7(strongly agree)
5. I like learning English.

(strongly disagree) 1---------2---------3---------4---------5---------6---------7(strongly agree)

6. When I speak English, I try my best to not use Portuguese.

(strongly disagree) 1---------2---------3---------4---------5---------6---------7(strongly agree)

7. I try to imitate the English accent as best as I can.

(strongly disagree) 1---------2---------3---------4---------5---------6---------7(strongly agree)

THANK YOU VERY MUCH!
APPENDIX F

Distribution of age of acquisition for Brazilian Portuguese learners of English across two levels of proficiency (1=lower-proficiency group; 2=higher-proficiency group).
APPENDIX G

Distribution of L2 use of Brazilian Portuguese learners of English across two levels of proficiency (L=lower-proficiency group; H=higher-proficiency group).
APPENDIX H

Summary of the reported self-perception of English skills provided by lower- and higher-proficiency groups of Brazilian Portuguese learners of English ($M$, $SD$). They responded by choosing on a scale from 1 (very low) to 7 (excellent).

<table>
<thead>
<tr>
<th>Self-reported English skills</th>
<th>Lower group</th>
<th></th>
<th>High group</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Speaking</td>
<td>3.78 (1.95)</td>
<td>4.39 (1.42)</td>
</tr>
<tr>
<td></td>
<td>Writing</td>
<td>4.44 (1.42)</td>
<td>4.5 (1.42)</td>
</tr>
<tr>
<td></td>
<td>Listening</td>
<td>4.44 (1.61)</td>
<td>3.89 (1.49)</td>
</tr>
<tr>
<td></td>
<td>Grammar</td>
<td>4.33 (1.41)</td>
<td>4.39 (1.29)</td>
</tr>
<tr>
<td></td>
<td>Vocabulary</td>
<td>4.33 (1.32)</td>
<td>4.56 (1.19)</td>
</tr>
<tr>
<td></td>
<td>Pronunciation</td>
<td>3.67 (1.74)</td>
<td>4.33 (1.71)</td>
</tr>
<tr>
<td></td>
<td>Reading</td>
<td>4.61 (1.50)</td>
<td>5.00 (1.37)</td>
</tr>
</tbody>
</table>
**APPENDIX I**

Responses provided by the lower- and higher-proficiency groups (\(M, SD\)) on their self-perception of motivation using a scale from 1 (strongly disagree) to 7 (strongly agree).

<table>
<thead>
<tr>
<th>Response</th>
<th>Lower-proficiency group</th>
<th>Higher-proficiency group</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>I am studying English because it will help me to get a better job.</em></td>
<td>5.61 (1.85)</td>
<td>6.16 (1.86)</td>
</tr>
<tr>
<td><em>I am studying English because I love the English/American culture.</em></td>
<td>5.5 (1.54)</td>
<td>6.05 (1.67)</td>
</tr>
<tr>
<td><em>Studying English makes me feel important.</em></td>
<td>5.27 (1.78)</td>
<td>5.22 (1.76)</td>
</tr>
<tr>
<td><em>I don’t want to stop studying English.</em></td>
<td>6.38 (1.09)</td>
<td>6.72 (1.10)</td>
</tr>
<tr>
<td><em>I like learning English.</em></td>
<td>6.44 (0.83)</td>
<td>6.83 (0.85)</td>
</tr>
<tr>
<td><em>When I speak English, I try my best to not use Portuguese.</em></td>
<td>5.27 (1.23)</td>
<td>6.33 (1.23)</td>
</tr>
<tr>
<td><em>I try to imitate the English accent as best as I can.</em></td>
<td>5.38 (1.49)</td>
<td>5.72 (1.59)</td>
</tr>
</tbody>
</table>
APPENDIX J

Graphic representation of L2 learners’ responses to Statement 6 (When I speak English, I try my best to not use Portuguese). Participants used a scale from 1 (strongly disagree) to 7 (strongly agree).
APPENDIX K

LANGUAGE BACKGROUND QUESTIONNAIRE
(para falantes monolingues do português brasileiro)

O questionário abaixo procura explorar a sua história linguística e o seu background. Fornecer respostas completas e corretas às perguntas é fundamental para o sucesso da minha pesquisa. MUITO OBRIGADA pelo seu tempo em responder o questionário.

Nome: __________________________________________  Participante n. __________
Telefone: _________________________  email: _____________________________
Data: ________________________

1. Você tem problemas de audição?     SIM    NÃO
2. Você tem visão normal ou corrigida?     YES    NO
3. Sexo:  M – F
4. Idade: _______________
5. Educação:
   (   ) Segundo grau – completo / incompleto
   (   ) Terceiro grau/universidade – completo / incompleto
   (   ) Pós-graduação – completo / incompleto
6. Local de nascimento (cidade/estado): ___________________________
7. Local onde você mora (cidade/estado) ___________________________
8. Há quanto tempo você mora neste local? ___________________________
9. Minha língua materna é ___________________________
10. Você já estudou outra língua sem ser inglês e português?   SIM    NÃO
    Se a resposta for SIM, que língua(s) estudou? ___________________________
    Por quanto tempo? ___________________________

MUITO OBRIGADO!
APPENDIX L

LANGUAGE BACKGROUND QUESTIONNAIRE
(for monolingual Brazilian Portuguese speakers)

The following survey seeks to explore your language history. Providing full and accurate answers to these questions is absolutely important for the success of this survey. THANK YOU for taking the time to answer this survey.

Name: __________________________________________ Participant n. ____________
Telephone: __________________________ email: __________________________
Date: __________________________

1. Do you have normal hearing? YES NO

2. Do you have normal or corrected vision? YES NO

3. Gender: M – F

4. Age: ____________

5. Education:
   (  ) High school – complete / incomplete
   (  ) College degree – complete / incomplete
   (  ) Graduate program – complete / incomplete

6. Birth place (city/state): _____________________________

7. Place where you live (city/state) _____________________________

8. How long do you live there? _____________________________

9. My native language is _____________________________

10. Do you speak another language besides Portuguese? YES NO
If YES, which one(s)? _____________________________

11. Have you studied this language at school? YES NO
If YES, for how long? _____________________________
What type of school? _____________________________

12. Have you lived in another place besides the city you live in now? YES NO
If YES, which city/state and for how long? _____________________________

THANK YOU VERY MUCH!
APPENDIX M

Script used to normalize for pitch intensity (created by Daniel Brenner at the University of Arizona).

```plaintext
dir$ = chooseDirectory$ ("Select the directory of .WAV files to be scaled...")
beginPause ("Intensity level")
    comment ("Dir: " + dir$)
    positive ("Level (dB SPL)", 75)
    comment ("CAUTION: this will replace the original files if you proceed.")
clicked = endPause ("Cancel", "Go!", 2, 1)
if clicked == 1
    exit Aborted
endif
filelist = Create Strings as file list... filelist 'dir$/*wav'
numfiles = Get number of strings
for i to numfiles
    select filelist
    wav$ = Get string... i
    wav = Read from file... 'dir$/wav$
    Scale intensity... level
    Save as WAV file... 'dir$/wav$
    Remove
endfor
select filelist
Remove
printline Donished!
```
APPENDIX N

Examples of pictures and the corresponding target word in the English and Portuguese sessions.

CAR

BALA
APPENDIX O

Script used to create individual sound files (created by Dr. Miquel Simonet at the University of Arizona).

form Save intervals to small sound files
    comment Give the folder where to save the sound files:
    sentence Folder /Volumes/My Passport/RESEARCH_Dissertation/DATA/data_engl_L2/data_repeat_L2/data_repeat_L2port/sound_working data_repeat_L2port/bsc_repeat_L2port
    comment Give an optional prefix for all filenames:
    sentence Prefix t
    comment Give an optional suffix for all filenames:
    sentence Suffix t
endform

soundname$ = selected$ ("TextGrid", 1)
select TextGrid 'soundname$
numberOfIntervals = Get number of intervals... 1
for interval to numberOfIntervals
    select TextGrid 'soundname$
    intname$ = Get label of interval... 1 interval
    check = 0
    if intname$ = "x"
        check = 1
    endif
    if check = 0
        intnumber = 10+'interval'
        intervalstart = Get starting point... 1 interval
        intervalend = Get end point... 1 interval
        select LongSound 'soundname$
        Extract part... intervalstart intervalend yes
        intervalfile$ = "prefix$" + intnumber + "suffix$"
        Rename... 'intervalfile$
        select TextGrid 'soundname$
        select Sound 'intervalfile$
        Write to binary file... 'folder$'/intervalfile$.wav
        Remove
    endif
endfor
APPENDIX P

Script used to mark the VOT boundaries (created by Dr. Miquel Simonet at the University of Arizona).

form Enter information
    comment Folders where files are kept:
    sentence dirFiles enter_folder_here
    comment Where do you want to start (continue)?
    positive start 1
endform

Create Strings as file list... soundFiles 'dirFiles$/*.wav
select Strings soundFiles
    clearinfo

numberOfFiles = Get number of strings

for each from start to numberOfFiles
    select Strings soundFiles
    soundName$ = Get string... each
    name$ = soundName$ - ".wav"
    Read from file... 'dirFiles$'/soundName$
    select Sound 'name$
    To TextGrid... "1 2 3 4" 1 2
    select Sound 'name$
    plus TextGrid 'name$
    Edit
    pause Continue?
    select TextGrid 'name$
    Write to binary file... 'dirFiles$'/name$.TextGrid
    select all
    minus Strings soundFiles
    Remove
    println "file number" 'each'
endfor
APPENDIX Q

Script used to export the VOT measurements annotated in each individual sound file (created by Daniel Brenner at the University of Arizona).

# Measure VOTs

# bitten on the leg 18 Apr 2015
# by dan brenner
# dbrenner ATMARK email DOT arizona DOT edu
#~#~#~#~#~#~#~#~#~#~#~#~#~#~#~#~#~#~

dir$ = chooseDirectory$: "Select the directory to find text grids."
datafile$ = dir$ + "/votdata.txt"
headers$ = "File" + tab$ + "Word" + tab$ + "Vowel" + tab$ + "BurstTime" + tab$ + "VoicingOnset" + tab$ + "VOT"
deleteFile: datafile$
appendFileLine: datafile$, headers$
tglist = Create Strings as file list: "TGlist", dir$ + "/*.TextGrid"
numfiles = Get number of strings
for i to numfiles
    selectObject: tglist
tg$ = Get string: i
tg = Read from file: dir$ + "/" + tg$
numpoints = Get number of points: 1
for p to numpoints
    voiceTime = Get time of point: 1, p
    wordint = Get interval at time: 3, voiceTime
    wordstart = Get start point: 3, wordint
    wordend = Get end point: 3, wordint
    burstPoint = Get high index from time: 2, wordstart
    burstTime = Get time of point: 2, burstPoint
    vowelint = Get interval at time: 4, voiceTime
    word$ = Get label of interval: 3, wordint
    vowel$ = Get label of interval: 4, vowelint
    if burstTime > wordend
        printline: "No burst indicated for <" + word$ + "> within word interval " + string$(wordint) + 
        goto LOOPEND
    endif
    vot = voiceTime - burstTime
    dataline$ = tg$ + tab$ + word$ + tab$ + vowel$ + tab$ + string$(burstTime) + tab$ + string$(voiceTime) + tab$ + string$(vot)
    appendFileLine: datafile$, dataline$
endfor
removeObject: tgfor
removeObject: tglist
appendInfo: "Acabado!"
APPENDIX R

A screen shot of the interface in the two-alternative forced-choice identification test in English.
APPENDIX S

A screen shot of the interface in the two-alternative forced-choice identification test in Portuguese.
REFERENCES


of the Acoustical Society of America, 54, 421–428.


