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**THE PRODUCTION OF ALVEOLAR PLOSIVES BY MULTILINGUAL
SPEAKERS OF PORTUGUESE-POLISH-ENGLISH**

Florianópolis

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Ficha de identificação da obra

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O presente trabalho em nível de mestrado foi avaliado e aprovado por banca examinadora composta pelos seguintes membros:

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Certificamos que esta é a **versão original e final** do trabalho de conclusão que foi julgado adequado para obtenção do título Mestre em Inglês: Estudos Linguísticos e Literários, na área de concentração Estudos da Linguagem.

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# RESUMO

No Brasil, cuja língua oficial é o português, a utilização da língua polonesa por descendentes de imigrantes poloneses é comum em diversas cidades da região sul. Além disso, o ensino da língua inglesa como língua adicional é obrigatório nas escolas do país. Desse modo, há pessoas nessa região que têm contato com os três idiomas, caracterizadas, assim, como falantes multilíngues. O presente estudo contou com cinco participantes, naturais da região do norte do estado de Santa Catarina e Sul do Paraná. O objetivo foi investigar a produção do *Voice Onset Time* (VOT) das oclusivas /d/ e /t/, nos idiomas inglês, português e polonês. Esses sons são produzidos com durações de VOT diferentes por falantes nativos de inglês (Lisker; Abramson, 1964), português (Klein, 1999) e polonês (Kopczyński, 1977). Portanto, buscou-se analisar quais as durações do VOT nesses três idiomas por falantes multilíngues. Para a coleta de dados, reuniões presenciais foram agendadas em seções individuais. Os sons-alvo foram incorporados em palavras-veículo que foram gravadas, e os segmentos-alvo foram analisados acústica e auditivamente com auxílio do programa Praat. Os resultados indicaram um nível de aspiração mais elevado em inglês do que em português e polonês. Além disso, a produção de VOT pelos falantes multilíngues indicou valores mais altos que os apresentados pela literatura em falantes monolíngues de português e polonês. Por outro lado, os valores produzidos pelos multilíngues foram mais baixos que os apresentados na literatura para falantes nativos do inglês. O presente estudo também buscou analisar o perfil linguístico dos participantes, com a finalidade de obter informações sobre a utilização, nível de proficiência e história de aprendizagem de cada idioma. Para esse procedimento, usou-se um questionário de histórico das línguas, baseado e adaptado de Scholl e Finger (2013). Constatou-se que, como descendentes de imigrantes poloneses, os participantes buscam manter viva a língua de herança, trazida ao Brasil por seus ancestrais, mesmo que, em alguns casos, o uso do polonês se dê a situações restritas. Além disso, por ser uma língua de herança passada de geração para geração oralmente, alguns participantes relataram obter maior proficiência nas habilidades de fala e escuta do polonês, enquanto que, para a escrita e leitura, o nível de proficiência tende a ser mais baixo. Situação inversa foi relatada para o inglês, pois os resultados indicam que os participantes têm maior proficiência em escrita e leitura em inglês e menor proficiência oral nessa língua adicional. No caso de português, todos os participantes relataram ter total domínio nas quatro habilidades: fala, escuta, leitura e escrita.

**Palavras-chave:** Voice Onset time. Multilinguismo. Língua de herança.

# ABSTRACT

In Brazil, where the official language is Portuguese, the use of the Polish language by descendants of Polish immigrants is common in several cities in the southern region. Furthermore, the teaching of English as an additional language is mandatory in the country's schools. Therefore, there are people in this region who have contact with these three languages, thus characterized as multilingual speakers. The present study included five participants, natives of the northern region of the state of *Santa Catarina* and southern *Paraná*. The objective was to investigate the production of Voice Onset Time (VOT) of the stops /d/ and /t/, in English, Portuguese and Polish. These sounds are produced with different VOT durations by native speakers of English (Lisker; Abramson, 1964), Portuguese (Klein, 1999) and Polish (Kopczyński, 1977). Therefore, we sought to analyze the VOT durations in these three languages by multilingual speakers. For data collection, in person meetings were scheduled in individual sections. The target sounds were embedded in carrier words that were recorded, and the target segments were acoustically and auditorily analyzed with the help of the Praat program. The results indicated a higher level of aspiration in English than in Portuguese and Polish. Furthermore, the production of VOT by multilingual speakers indicated higher values than those presented in the literature for monolingual speakers of Portuguese and Polish; while for English, the values produced by multilinguals were lower than those presented in the literature for native speakers of English. The present study also aimed to analyze the linguistic profile of the participants, with the purpose of getting information about the use, level of proficiency and history of each language. For this procedure, a linguistic background questionnaire was used, based and adapted from Scholl and Finger (2013). It was verified that, as descendants of Polish immigrants, the participants try to keep their heritage language alive. Even though, in some cases, the use of Polish is restricted to some situations. Furthermore, as it is a heritage language passed from generation to generation orally, some participants reported having higher proficiency in the speaking and listening skills, while for writing and reading, the level of proficiency was lower. Conversely, for English, the results demonstrated that the participants reported having a higher proficiency level in the writing and reading skills than in the oral skills. In case of Portuguese, all participants reported having a total command of the four skills: speaking, listening, reading and writing.

**Keywords:** Voice Onset Time. Multilingualism. Heritage language.

# PODSUMOWANIE

W Brazylii, której językiem urzędowym jest portugalski, używanie języka polskiego przez potomków polskich imigrantów jest powszechne w różnych miastach na południu kraju. Ponadto nauczanie języka angielskiego jako języka dodatkowego jest obowiązkowe w szkołach w tym kraju. W rezultacie w regionie tym są ludzie, którzy mają kontakt ze wszystkimi trzema językami i dlatego są określani jako osoby wielojęzyczne. W badaniu wzięło udział pięciu uczestników z północnej części stanu Santa Catarina i południowego stanu Parana. Celem było zbadanie czasu uzyskania *Voice Onset Time* (VOT) głosek zwarto-wybuchowych /d/ i /t/ w języku angielskim, portugalskim i polskim. Dźwięki te są wytwarzane z różnym czasem trwania VOT przez rodzimych użytkowników języka angielskiego (Lisker; Abramson, 1964), portugalskiego (Klein, 1999) i polskiego (Kopczyński, 1977). Dlatego też staraliśmy się przeanalizować czas trwania VOT w tych trzech językach przez osoby wielojęzyczne. W celu zebrania danych zaplanowano spotkania osobiste w poszczególnych sekcjach. Dźwięki docelowe zostały włączone do nagranych głównych słów, a segmenty docelowe zostały przeanalizowane akustycznie i słuchowo za pomocą oprogramowania Praat. Wyniki wskazały na wyższy poziom wdechu w języku angielskim niż w języku portugalskim i polskim. Ponadto, wartości VOT wytwarzane przez wielojęzycznych użytkowników języka wskazywały na wyższe wartości niż te prezentowane w literaturze dla jednojęzycznych użytkowników języka portugalskiego i polskiego. Z drugiej strony, wartości wytwarzane przez osoby wielojęzyczne były niższe niż te prezentowane w literaturze dla rodzimych użytkowników języka angielskiego. Niniejsze badanie miało również na celu analizę profilu językowego uczestników celem uzyskania informacji na temat ich użycia języka, poziomu biegłości i historii nauki każdego języka. Do tej procedury wykorzystano kwestionariusz historii językowej, oparty i przystosowany z Scholl i Finger (2013). Zauważono, że jako potomkowie polskich imigrantów, uczestnicy starają się zachować w użyciu swój język dziedziczony, przywieziony do Brazylii przez przodków, nawet jeśli w niektórych przypadkach stosowanie języka polskiego jest ograniczone do określonych sytuacji. Ponadto, ponieważ jest to język dziedziczony przekazywany ustnie z pokolenia na pokolenie, niektórzy uczestnicy zgłaszali większą biegłość w mówieniu i słuchaniu po polsku, podczas gdy w przypadku pisania i czytania poziom biegłości był zwykle niższy. Odwrotną sytuację odnotowano w przypadku języka angielskiego, gdyż wyniki wskazują, że uczestnicy mają wyższą biegłość w pisaniu i czytaniu po angielsku oraz niższą biegłość ustną w tym dodatkowym języku. W przypadku języka portugalskiego wszyscy uczestnicy zgłosili pełną biegłość we wszystkich czterech umiejętnościach: mówieniu, słuchaniu, czytaniu i pisaniu.

**Słowa-klucze:** Voice Onset time. Wielojęzyczność. Język dziedzictwa.

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| | |
|---|---|
| BP | Brazilian Portuguese |
| COCA | Corpus of Contemporary American English |
| CPN | Corpus *do Português* NOW (Corpus of Portuguese) |
| F2 | Second formant |
| Hz | Hertz |
| L1 | First Language |
| L2 | Second Language |
| L3 | Third Language |
| Ms | millisecond |
| NKJP | *Narodowy Korpus Języka Polskiego* (National Corpus of Polish) |
| P1 | Participant 1 |
| P2 | Participant 2 |
| P3 | Participant 3 |
| P4 | Participant 4 |
| P5 | Participant 5 |
| RoF | Rank of Frequency |
| SD | Standard Deviation |
| UFSC | *Universidade Federal de Santa Catarina* |
| UNESPAR | *Universidade Estadual do Paraná* |
| VOT | Voice Onset Time |

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# 1 INTRODUCTION

In this society, where globalization becomes always more present, being fluent in more than one language facilitates many aspects in an individual's life, whether professionally, as for work, communication and comprehension, or personally, as for trips and cultural enrichment. Besides acquiring a language that can be relevant for a professional career, many people also try to preserve their ancestors' languages; such is the case for many Polish families that migrated to the south of Brazil in the 19th and 20th centuries. When a person speaks several languages, then emerges what can be called multilingualism. There are different definitions and conceptions for the term multilingualism, which we will discuss in the Review of Literature chapter. In this study we adopt a view followed by many researchers, who use the term bilingual to refer to people who speak two languages, and multilingual for those who speak three or more (De Groot, 2011).

In multilingual learning, it is normal that the first language (L1) influences the second language (L2) or third language (L3) acquisition, concerning both formal aspects, such as phonology, orthography, morphology and syntax; and aspects of meaning, pragmatics and discourse (Peukert, 2015). For this study, the focus is on the analysis of data in the fields of phonetics and phonology. The data comes from Polish descendants living in the south of Brazil.

The south of Brazil has a huge number of Polish descendants (cf. Table 1). Many of their ancestors came to Brazil to replace the slave work or to flee countries such as Russia, Germany and Austria. As explained by Wachowicz (1970), from the 19th century onwards, there was an extraordinary population growth in western European countries. This event brought great transformations, such as excess of proletarian labor, lack of land for the new generations, absence of adequate agrarian legislation, rural exodus, political and religious persecutions. These events led many Europeans to emigrate and settle in newly emancipated and almost depopulated countries in America (Wachowicz, 1970). With the objective of summarizing the influx of Polish immigrants to Brazil, Głuchowicz (2005) developed a table to present these numbers until the year of 1914 (cf. Table 1). However, the table only demonstrates the original immigration from Poland and not the internal migration, i.e., the movement of people within national states. Some immigrants may just have moved to another state after their arrival in Brazil.

Table 1: Settlement of Polish immigration to Brazil – period 1871-1914

| Location | until 1889 | 1890-1894 | 1895-1900 | 1900-1914 | Total |
|---|---|---|---|---|---|
| PR | 6,530 | 14,286 | 6,100 | 14,730 | 41,646 |
| RS | 300 | 27,000 | | 7,000 | 34,300 |
| SP | | 13,500 | | | 13,500 |
| SC | 750 | 5,000 | | 1,000 | 6,750 |
| Other states | 500 | 5,000 | 500 | 2,000 | 8,000 |
| **Total** | **8,080** | **64,786** | **6,600** | **24,730** | **104,196** |

Source: (Głuchowski, 2005, p. 45)

In 1939, the Polish organizations[1] estimated 220,000 Polish immigrants in Brazil. From those, 90,000 in Paraná, 80,000 in Rio Grande do Sul and 27,000 in Santa Catarina, and these numbers represented, respectively, 9%, 3% and 2% of these states' population (Ferreira, 2019). Ferreira also points out that it was estimated a number of 30,000 Polish immigrants in Brazil after the World War II. In the 1970s, 100 years of Polish immigration to Brazil was celebrated, some estimates were conducted to try to elicit how many people living in Brazilian lands were of Polish ethnicity. However, there was not agreement in the results, with estimates ranging from 400,000 to 850,000 (Brożek, 1972, p. 263 apud Kula, 1981, apud Ferreira, 2019, p. 34. Zając, 1971, p. 150, apud Ferreira, 2019, p. 34). This situation was due to the fact that since the first Polish immigrants arrived in Brazil, some of them did not have documents and, thus, were classified as belonging to other ethnic groups. Another fact was that Poland was not an independent country during the 19th and beginning of the 20th centuries. Thus, the Polish citizens came to Brazil as German, Austrian or Russian.

In Brazil, many Polish descendants maintained their culture, such as dances, cuisine, music and language. For some time, families used to teach their children Polish as their first language. After some time, the effort to preserve the heritage language was abandoned by many families. Gluchowski (2005) states that the frequent loss of the Polish language by the descendants are mostly caused by the substitution of the Portuguese language. The causes were

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[1] The census involved some institutions: The World Association of Poles Abroad, the local Polish organizations and the General Consulate of Curitiba.

the necessity to speak more Portuguese in social circumstances, marriages with other ethnical groups, which made unfeasible the possibility to speak Polish, among other reasons.

Polish as a Heritage language is here defined as the language in which the speakers are designated heritage speakers, i.e., second (or third) generation emigrants who acquire two languages in childhood in acquisition contexts divided between the family space and the social space outside the family (which includes school) and can have partial and quite diversified levels of proficiency (Flores; Melo-Pfeifer, 2014).

Costa (2020) states that in 1940, there were 22,521 Polish immigrants who declared to speak Polish in Brazil, and the actual number of Polish descendants was 38,129. From that period to now, the census surveys do not provide information about the number of Polish speakers (Costa, 2020). Nowadays, there are still some Polish descendant families that use the Polish language, even though it is sometimes only used in restricted situations. Another point is that heritage language speakers may have a low development literacy or even illiterate than in the majority language (Montrul, 2010). Thus, as Polish is a heritage language for these families, the speakers may not be fluent in all of the skills, since the language is passed from generation to generation orally. Some of them can have a good level of speaking and listening, and a basic command of writing and reading.

Given the fact that Polish is a heritage language for a number of families residing in the south of Brazil, it is interesting to investigate how this heritage language can influence the phonological development of Portuguese (the official language in the context where the families of Polish descendants live), and of English, as a mandatory additional language in Brazilian schools. This study investigates the phonemes /t/ and /d/ and how they are produced in the three languages, in onset position, by Polish descendants residing in the south of Brazil. The choice for analysis is mainly based on the methodology proposed by sociophonetic studies, as outlined by Di Paolo and Yaeger-Dror (2011):

> stops present many opportunities for variation, since in principle any aspect of the articulatory chain at events may differ: the magnitude, direction, and speed of the closing articulation, the location and duration of the closure, the strength, speed, and direction of the release, and the timing of these events relative to other articulatory action such as phonation (Di Paolo; Yaeger-Dror, 2011, p. 58).

The Portuguese /t/ is defined by Silva, Seara, Rauber et al. (2019) as a stop, alveolar and unvoiced consonant phoneme; whereas /d/ is a stop, alveolar and voiced consonant phoneme. However, Silva (1999) states that /t/ and /d/ can have a dental articulation in the production of some Brazilian Portuguese speakers. In Polish, Janusz (2002) defines /t/ as a stop, dental and unvoiced phoneme; whereas /d/ is a stop, dental and voiced phoneme. English has both consonants as phonemes as well, and Ladefoged and Johnson (2011) define /t/ as a stop, alveolar and unvoiced phoneme, and /d/ is a stop, alveolar and voiced phoneme. Thus, we see that there is a difference in the manner of articulation of these same phonemes when we compare the phonetic description of the two phonemes in Polish, Portuguese and English, with the Polish articulation involving a dental gesture, while English sounds involve an alveolar gesture and Brazilian Portuguese can have both, dental and alveolar gestures.

For this study, the purpose is to conduct an acoustic analysis of the stop phonemes /t/ and /d/, and compare their production in the three languages spoken by the participants. The participants in this study are Brazilians, descendants of Polish immigrants. They all have Brazilian Portuguese as their L1, some of them have Polish as their L2 and English as their L3; others have English as their L2 and Polish as their L3. A better glimpse of how the participants learned and use the three languages will be provided with the help of a background questionnaire. The participants are originally from cities in the region of *Porto União,* North of *Santa Catarina* and *União da Vitória,* South of *Paraná,* in the border of the states (cf. Figure 5). The characteristic to be analyzed is the VOT (voiced onset time), which refers to the moment of the release of the closure and the starting of voicing, its characteristics will be better explained in the review of literature.

## 1.1 SIGNIFICANCE OF THE STUDY

South of Brazil has an ethnic diversity, as demonstrated by studies investigating different ethnic groups. This diversity can offer researchers a great amount of options for linguistic investigations, although some ethnical groups seem to be more investigated than others, for example, German descendants (Brito, 2011; Santos, 2013); Italian descendants (Balthazar, 2016; Comiotto, Margotti, 2019). *Santa Catarina* and *Paraná* states, in south of Brazil, have a huge number of Polish descendants, and many of them still keep their ancestor's

language alive nowadays. Even though, there have been a few studies involving Polish descendants, (e.g., Ryba, 2019; Zaremba, 2021), it is still an open field for other studies, especially when we consider multilingual phonological development. To the best of our knowledge, we still lack studies that investigate crosslinguistic[2] influences in the phonological development of multilingual Polish descendants in the south of Brazil. The studies investigating Brazilian Polish descendant speakers are, most of them, driven around bilingualism, (e.g., vowel production: Mileski, 2017; sociological profiles: Nunes, 2018). Thus, through this study we seek to contribute to the fields of phonetics and phonology, sociophonetics and multilingualism by investigating the production of specific consonants produced by a group of Portuguese-Polish-English multilinguals.

## 1.2 ORGANIZATION OF THE THESIS

This research is composed on the following chapters: the first chapter highlights the field of this study, as well the problem of investigation. The second chapter focuses on the review of the literature, discussing approaches to multilingualism and L2 and L3 research relevant for this study, as well as describing the consonant sound being investigated in the present study. In the third chapter, the method employed in the study is explained, presenting details about participants' sociolinguistic backgrounds. We also present the instruments for data collection, how the data collection procedure took place, and the procedures for data analysis. In chapter four, we present the results and discuss them, aiming to answer the research questions. The thesis ends with a summary of the main findings and the final remarks about pedagogical implications and directions for future research, in chapter 5.

## 1.3 OBJECTIVES

This section describes the main and specific objectives, which are taken into account to the development of this research.

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[2] A phenomenon of language learning, bilingualism, and multilingualism, crosslinguistic influence is related to the knowledge of one language that can affect a person's comprehension of another language, oral or written (Jarvis; Pavlenko, 2008).

### 1.3.1 Main objective

The main objective of this research is the analysis of how the stops /t/ and /d/ are produced by multilingual speakers in Portuguese, Polish and English and, therefore, describe possible crosslinguistic influence in the production of these sounds by multilingual speakers.

### 1.3.2 Specific objectives

- To analyze the duration of Voice Onset Time (VOT) of the stops /t/ and /d/ in Portuguese, Polish and English;
- To examine how the linguistic experiences of Portuguese-Polish-English multilingual speakers affect their productions of the target sounds.

### 1.3.3 Research questions

Based on the objectives, this study will seek to answer the following research questions:

RQ1: What is the VOT duration of the stops /t/ and /d/ produced by multilingual speakers in Portuguese, English and Polish words?

RQ2: How do linguistic experiences affect the production of the target consonants by multilingual speakers?

## 2    REVIEW OF THE LITERATURE

This chapter provides the literature that will serve as a base for this study. In section 2.1, we discuss features of stop consonants, and we provide information about the stop consonants /t/ and /d/, the target sounds of this study. In section 2.2, we introduce the concept of VOT. Section 2.3 presents the characteristics of English VOT, as well as a review of studies investigating production of stops in English. Section 2.4 brings information about studies that investigated Brazilian Portuguese VOT. In section 2.5, we review some studies Polish VOT. Section 2.6 has a discussion of English as an L2, in Portuguese and Polish L1 contexts. In section 2.7, we address the topic of crosslinguistic influences regarding phonetics and phonology.

## 2.1 CHARACTERISTICS OF STOP CONSONANTS

For production of the stop consonants there is a total closure of the oral cavity. The air coming from the lungs is blocked temporally and a silence can be noticed. It happens because there is a contact between some articulators. After the articulators are separate, the airstream is released, causing, thus, an explosion. This procedure occurs for all stop consonants: /p/, /b/, /t/, /d/, /k/, /g/. Furthermore, stops are also classified according to their place of articulation: for /p/ and /b/, the lips are responsible for producing the sounds, thus they are bilabial stops; /t/ and /d/ are produced by the tongue touching the alveolar ridge[3], thus they are called alveolar stops; and /k/ and /g/ are produced when the back of the tongue touches the soft palate, also known as velum, thus, velar stops (Yavaş, 2011).

The stops are classified as voiceless or voiced sounds. Those sounds that have vibration of the vocal folds before or at the moment of the release of the obstruction are voiced: /b, d, g/; while if there is no vibration until the next segment is produced, then it is a voiceless sound: /p, t, k/. Thus, voicing is a parameter that differentiates /p,t,k/ and /b,d,g/. However, Lisker and Abramson (1964) state that, even though for medial position English has /b/, /d/ and /g/ as voiced, and /p/, /t/ and /k/ as voiceless consonants, for initial position, both groups are normally

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[3] As pointed out in section 1, these sounds can also be produced with a dental place of articulation in some languages.

produced with silence closure intervals and, therefore, should be classified as voiceless. But, they also point out that phoneticians rarely indicate /b/, /d/ and /g/ as voiceless stops, the commonest feature indicated is the aspiration (Lisker; Abramson, 1964). Aspiration is defined by Ladefoged and Johnson as, "a period of voicelessness after the stop articulation and before the start of the voicing for the vowel" (Ladefoged; Johnson, 2011, p. 57). In phonetic transcriptions, "aspiration is indicated by a small raised $h$ [$^h$]" (Ladefoged; Johnson, 2011, p. 57). In waveforms, aspiration presents semi-random variations just after the stop closure is released. An example can be seen in Figure 1:

Figure 1: The waveforms of the words *tie* and *die*:
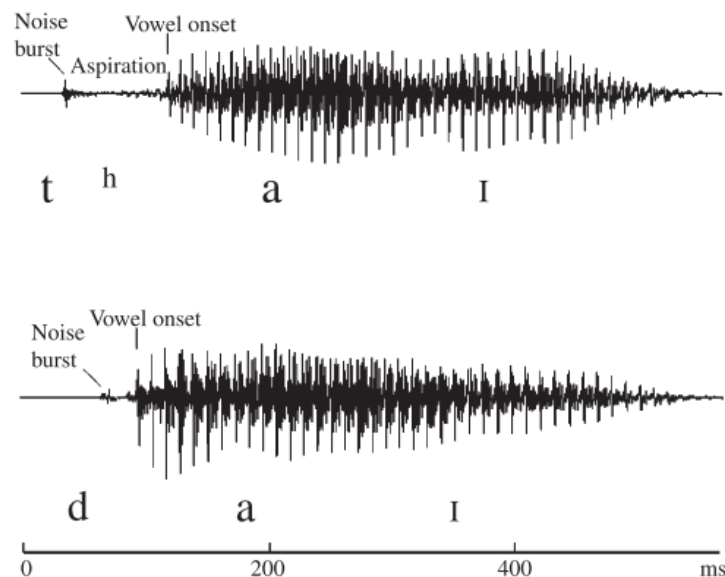


Source: (Ladefoged; Johnson, 2011, p. 58)

As explained by Ladefoged and Johnson (2011), the distinction between aspirated and unaspirated stops relies on the different time duration "between the release of the stop and the start of the vowel" (p. 58), measured in milliseconds (ms) by software used to conduct acoustic analysis. Cho and Ladefoged (1999) present reference values for English unaspirated stops, slightly aspirated stops, aspirated stops and highly aspirated stops, as displayed in Table 2.

Table 2: VOT values for English aspirated and unaspirated stops

| Duration | Classification |
|---|---|
| 0 ms – 34 ms | unaspirated stops |
| 35 ms – 54 ms | slightly aspirated stops |
| 55 ms – 94 ms | aspirated stops |
| 95 ms – 150 ms | highly aspirated stops |

Source: Cho and Ladefoged (1999, p. 223)

### 2.2.1 The target sounds of the present study

The same way as Portuguese and English, the Polish language also has the alveolar stops /t/ and /d/ in its phonemic inventory. However, while in Portuguese (Silva et al., 2019) and in English (Ladefoged; Johnson, 2011) these phonemes are produced with the tongue touching the alveolar ridge, in Polish (Janusz, 2002) /t/ and /d/ are produced as dental sounds. Thus, in Polish, the two phonemes are produced with a slightly different point of articulation. Janusz also classifies /t/ and /d/ as plosive sounds, /t/ unvoiced and /d/ voiced. However, Gussmann (2007), explains that when these phonemes are followed by a high front vowel, their articulation becomes dental palatalized, /dʲ/ and /tʲ/. In Polish, this process appears mostly in loan words (e.g., *adiustacja* /adʲjustatsja/ 'edit', *partia* /partʲa/ 'party'), but it may also be observed in Polish words (e.g., *diament* /dʲˈamɛnt/ 'diamond', *dieta* /dʲˈɛta/ 'diet', *plastik* /plastʲk/ 'plastic'). Differently, in BP, palatalization occurs with more frequency when /t/ and /d/ are followed by a high front vowel (e.g., Battisti et al., 2007; Dias, 2009).

In this study, the production of Polish descendants from cities located in the border of Santa Catarina and Paraná states is analyzed, and it is important to bear in mind that these Polish descendants might produce the /t/ and /d/ phonemes different from the production that was just described for native speakers of Polish. The first Pole immigrants arrived in Brazil by the end of the 19th century. Thus, it is possible that the Polish spoken in Brazil may have some differences to the European Polish. Nonetheless, the communication with Europeans by Brazilian descendants of Polish immigrants is possible. In Brazil, the production of Polish /t/ and /d/ was analyzed in the city of Mallet – PR by Costa (2016), who demonstrated that the Polish descendants tended to produce /t/ and /d/ with a more front articulation, i.e., dental. Thus,

the difference in the point of articulation of /t/ and /d/ is possibly not a particularity of the Polish spoken in Europe. Furthermore, the difference in the articulatory production is also a fact when we compare /t/ and /d/ in Polish and Brazilian Portuguese: while Polish /t/ and /d/ are dental, in Brazilian Portuguese they can be both, alveolar or dental.

When analyzing stops, it is important to consider the differences in the language's systems, Portuguese and Polish. Costa (2016) calls attention to the role of affricates: "In Portuguese, as we know, the affricate productively occurs as a contextual variant of the alveolar stop before the vowel /i. In European Polish and in the Polish spoken in Mallet, affricates occur with all vowels and at various points of articulation." (Costa, 2016, p. 65).[4] This means that the same phenomenon occurs in both, Polish from Europe and Polish spoken in Brazil, that is, affricate sounds are produced before any vowel, whereas in Portuguese only before the high vowel /i/. The author also points out that the point of articulation of stop consonants can be evidenced by the F2 values of the adjacent vowel of the stop. The higher the values of F2, the more anterior the point of articulation. As Costa (2016) explains, "according to Kent and Read (1992) a possible unifying feature of various transitions is the initial frequency or locus of the second vowel formant. For bilabial /b/, the initial frequency of F2 is always very low, around 600-800Hz; for alveolar /d/, the initial frequency of F2 is around 1800Hz."[5] Table 4, simplifies the Polish consonant system.

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[4] Our translation.
[5] Our translation.

Table 3: The consonant inventory of Polish

| place/manner of articulation | | bilabial | labio-dental | dental | alveolar | palato-alveolar | palatal | velar |
|---|---|---|---|---|---|---|---|---|
| plosive | | p | | t | | | | k |
| | | b | | d | | | | g |
| fricative | | | f* | s | ʃ | ɕ | | x |
| | | | v | z | ʒ | ʐ | | |
| affricate | | | | ts | tʃ | tɕ | | |
| | | | | dz | dʒ | dʐ | | |
| nasal | | m | | n | | | ɲ | |
| | | | | | | | | |
| liquid | lateral | | | | | | l | |
| | rhotic | | | | | | r | |
| glide | | w | | | | | j | |

Source: Szreder (2013, p.90)

In Brazilian Portuguese, /t/ is classified as a voiceless sound and /d/ as a voiced sound, both alveolar, since they are produced with the tongue touching the alveolar ridge. According to Silva et al. (2019), the acoustic characteristics of these stops are: 1. Absence of energy: the moment of blockage of the air passage in the vocal tract. 2. Voicing: the waveform presents regular and low amplitude values. Thus, it is present in /d/ and absent in /t/. 3. Burst: reflects the moment of separation of the two articulators and occurs immediately after the release of the occlusion, it may or may not be present in a stop consonant. 4. Voice Onset Time. 5. F2: it corresponds to the value of F2 obtained at the point of transition from the stop consonant to the vowel that follows it. 6. Spectral configuration of the burst: it corresponds to the frequency peaks in the spectrum.

## 2.2 VOICE ONSET TIME

The time between the release of closure and start of voicing is named voice onset time (VOT). VOT is measured in milliseconds (ms) and is classified by Lisker and Abramson (1964)

into three conditions: voicing lead, short voicing lag and long voicing lag. The voicing lead is denominated when the voicing begins before the release of the stop and has negative values. In short voicing lag, the release occurs with the vocal folds apart during the closure period, but together when there is the release of the closure; it has positive values. In long voicing lag, the release is voiceless and aspirated, and for its production, the vocal folds are apart during the stop closure and, at the moment of the release of the stop closure, the glottis is still open. The long voicing also has positive values.

Figure 2: Voice Onset Time values
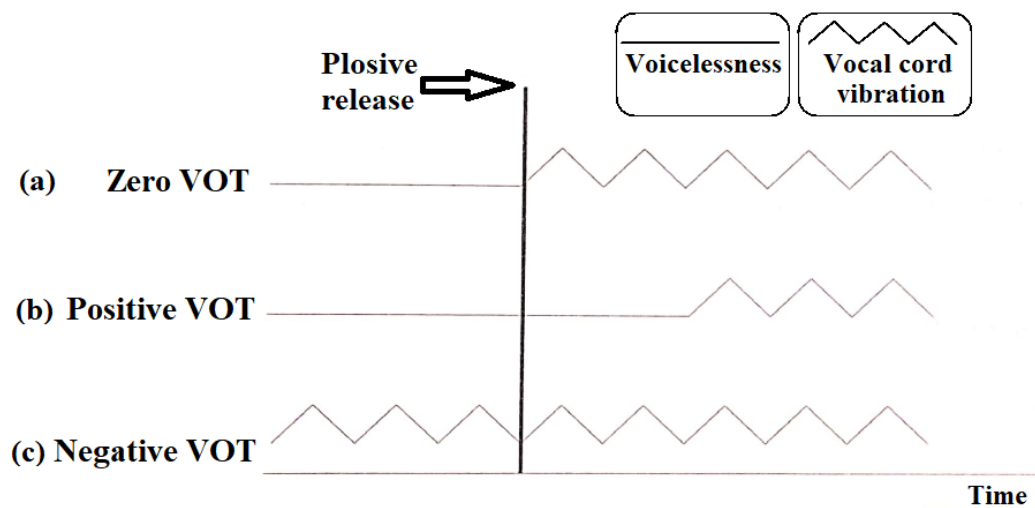


Source: The author, adaptation from Cohen (2004).

Figure 2 illustrates the zero, positive and negative VOTs. The vertical line represents the moment of the release. The straight line represents the voicelessness, and the zigzag line indicates the voicing presence.

VOT is positive (line (b)) when the release of the closure occurs before the beginning of voicing, i.e., voicing starts after the release of the stop closure, thus, having a voice lag. Depending on the amount of lag in milliseconds, they can be described as aspirated or unaspirated stops (cf. Table 3).

VOT is negative when the release of the closure occurs after the beginning of voicing, i.e., voicing starts during the closure period. For representing the negative VOT, a minus sign is used before the value in milliseconds. The zigzag line in Figure 2, line (c), represents a fully voiced stop, i.e., the vocal cords vibrate throughout the closure and continue after the release.

This occurrence is typical of /b, d, g/ in Romance languages, as Brazilian Portuguese. But there are also situations in which there is a loss of voicing, being, then, partially devoiced during the production, as is the case of English. In such circumstance, voicing starts some time during the closure and continues up to the following vowel (Yavaş, 2011).

The VOT value is zero when the release of the closure occurs at the exact moment of the beginning of voicing, and it does not present any difference in milliseconds. In such case, there is a voiceless unaspirated stop. Examples of this kind of productions are voiceless stops in Romance languages (Yavaş, 2011). Different languages can have different VOT patterns for voiced and voiceless consonants.

As stated by Ladefoged and Johnson (2011), the VOT values can vary from one language to another, since the air release can be different. Thus, the VOT values may differ depending on some factors as well, such as age, gender, language use and dominance. Furthermore, the VOT duration depends on phonetic conditioning, such as the following vowel's height, variation in stress, the context, i.e., if the stimulus is produced in an isolated word or as part of an utterance (Ladefoged; Johnson, 2011). Klein (1999) indicates that there are influences in the VOT duration for BP depending on the vowel that follows the voiced stop consonants, considering whether they are isolated or inserted in a sentence. Table 4 presents Klein's results.

Table 4: Mean VOT, in (ms), of voiced and unvoiced stop consonants in Brazilian Portuguese, followed by different vowels

| | **Isolated words** | | | | **Words in a sentence** | | |
|---|---|---|---|---|---|---|---|
| | /a/ | /e/ | /o/ | | /a/ | /e/ | /o/ |
| **/b/** | -91.84 | -81.43 | -87.92 | | -106.88 | -108.80 | -99.25 |
| **/d/** | -89.15 | -110.51 | -96.85 | | -85.15 | -100.42 | -95.02 |
| **/g/** | -88.46 | -99.14 | -82.38 | | -68.11 | -87.73 | -79.84 |
| **/p/** | 11.34 | 13.98 | 27.77 | | 12.51 | 14.11 | 19.84 |
| **/t/** | 14.03 | 18.64 | 17.67 | | 15.07 | 19.19 | 17.13 |
| **/k/** | 33.84 | 40.67 | 39.04 | | 29.68 | 36.37 | 35.83 |

Source: Klein (1999)

From the results presented by Klein (1999), it is notable that there is a difference between VOT values in isolated words and words in a sentence for voiced sounds. In voiced sounds, the bilabial /b/ was the only one that had higher mean values in words in the sentence than in isolated words. The obtained VOT values for /b/ in isolated words before /a/, /e/ and /o/ do not present considerable differences. Differently, in sentences, the mean VOT for the bilabial /b/ before /o/ had a significant lower value than /a/ and /e/.

In the case of the alveolar /d/, we see that, in isolated words, the mean VOT before /e/ was significantly higher than /a/ and /o/. Whereas in sentences, before the vowels /e/ and /o/, /d/ presented mean VOT higher than before /a/. The velar /g/, presented a higher VOT before the vowel /e/ in both isolated words and sentence contexts.

All the results presented for voiceless sounds did not have statistically significant differences. The highest variation was the bilabial /p/, which had a higher value of almost 8 ms in sentences than in isolated words when followed by the vowel /o/.

The author concludes that the vowel context influences the stop consonants production. However, these influences are asymmetric through the different points of articulation. Moreover, Lisker and Abramson (1964)'s claim that the VOT values would present reduction when the target words are part of utterances was confirmed for the bilabial /b/ before /a/, /e/ and /o/; for the velar /g/ before /a/ and /e/; and for the alveolar /d/, only before /e/ (Klein, 1999).

Although, there are many factors that can influence the VOT production, some studies present values of reference for Brazilian Portuguese (BP), Polish and English. The next sections will bring these mean values. Since this study analyzed the production of adults, our literature review also discusses some studies involving adult's production.

2.3 ENGLISH VOICE ONSET TIME

As well as Polish and Portuguese, English has two categories for stop consonants: voiced and voiceless. However, English has different phonetic realization for these sounds. The English initial /p/, /t/ and /k/ are around 60-80 ms, thus, they are usually produced as long-lag stops and are categorized as voiceless aspirated when produced in stressed position, followed by a vowel (Yavaş, 2011). Yavaş (2011) brings a discussion concerning the stop consonants voicing categorization in English. While their place of articulation is straightforward, i.e., /p/

and /b/ are bilabial stops; /t/ and /d/ are alveolar stops; and /k/ and /g/ are velar stops; their voicing is not likewise straightforward. The stops /p, t, k/ are commonly labeled as voiceless and the stops /b, d, g/ as voiced. That definition is true for the voiceless stops, but not entirely true for the voiced ones. Indeed, /b, d, g/ can be categorized as voiced stops in several languages. In English, that occurrence exists only in intervocalic position, i.e., when the stop consonant is between two vowels, e.g., 'abord' /əˈbɔːrd/. When following or preceding silence, in initial and final position, the stops /b, d, g/ are partially voiced. (Yavaş, 2011).

Yavaş (2011) also points out that many phoneticians prefer to use the terms fortis and lenis to differentiate /p, t, k/ from /b, d, g/. "This is because, fortis stops /p, t, k/ are pronounced with more muscular energy (force), higher intra-oral pressure, and a stronger breath effort than their lenis counterparts /b, d, g/." (Yavaş, 2011, p. 58).

For English VOT, we start discussing about the means presented by Lisker and Abramson (1964), which refers to speakers of American English. Their work is relevant because they were pioneers in investigating this parameter. Their data were collected from four speakers. It is important to notice that the authors provide two sets of means for /b/, /d/ and /g/. They stated that having one mean of the values would be misleading, since it would get together positive and negative values.

Both, Lisker and Abramson's (1967) and Baran et al.'s (1977) results indicate that the production of voiceless stops had longer values when being read from wordlists than when in connected speech, i.e., in conversation and/or reading sentences, while voiced stops were more frequently read with prevoicing in wordlists than in connected speech. Baran et al.'s (1977) study was conducted in four different conditions. In the first one, the data were collected in wordlist form; for the second one, it included adult-to-child speech; the third one, adult-to-adult conversation; and the last one, oral reading.

Chodroff et al. (2015) analyzed the VOT production in word-initial position of /p/, /t/, /k/, /b/, /d/, and /g/ in more than 100 native speakers of American English, aged from 19 to 87 years old, and the gender was roughly balanced. The results from Chodroff et al. (2015) research show an agreement in VOT means with the studies previously mentioned. The alveolar /d/ was the only stop that presented the highest VOT mean value, but it was not a surprising value, because the difference concerning other results was not large.

In the present study, we use Lisker and Abramson (1964)'s reference for the English VOT. The reference value for the voiceless stop /t/ is 70 ms, while for the voiced stop /d/, it is 5/-102 ms. A table presenting the full results of the English studies mentioned in this section is available in Appendix A.

## 2.4 BRAZILIAN PORTUGUESE (BP) VOICE ONSET TIME

According to Istre (1980)[6] apud (Kupske; Alves, 2016), the BP VOT is characterized by having a short-lag and the voiced stops (/b/, /d/ and /g/) have the beginning of voicing before the release of closure, i.e., they have negative VOT values. And according to Reis and Nobre-Oliveira, the voiceless stops (/p/, /t/ and /k/) in BP are commonly produced with positive VOT, but short values. Some authors state that the BP voiceless stops can fit in the zero VOT group (Reis; Nobre-Oliveira, 2007).

Klein (1999) conducted a study and obtained VOT means values for BP. The researcher collected data from four participants, two men and two women, native speakers of BP. The data collection consisted of a reading test with words inserted in sentences and isolated words. The results for the voiced and voiceless stops before different vowels were presented in Table 2, but they will be reproduced in Table 5, with the mean results for voiced and voiceless stops. Klein (1999)'s VOT values are used as refence in the present study.

Table 5. Klein's VOT reference values for BP stops in ms

|  | /p/ | /b/ | /t/ | /d/ | /k/ | /g/ |
|---|---|---|---|---|---|---|
| **Isolated words** | 17.70 | -86.57 | 16.78 | -99.20 | 37.82 | -91.16 |
| **Sentences** | 15.49 | -104.98 | 17.13 | -93.31 | 33.90 | -76.93 |

Source: the author

Klein (1999) reported that /p/ in isolated words had a small reduction, varying from 5 ms to 25 ms. For /b/ in isolated words, the mean was -86,57, varying from -162,65 ms to -26,70 ms. The /t/ production did not have considerable differences concerning isolated words and

[6] Unpublished manuscript.

sentences, since the mean was 16,78 ms in isolated words and 17.13 in sentences. Conversely, /d/ presented a reduction when inserted in sentences (-93.31); in isolated words the mean was -99.20 ms, and a similar result was obtained for /k/ (isolated words: 37,85 ms; sentences 33.90 ms). The velar stop /g/ also displayed lower value when inserted in a sentence (-76.93) than in isolated words, with the latter yielding -91,16 ms.

Alves et al. (2008) conducted research about voiceless stops focusing on aspiration. They considered that some productions of stops in BP could be included in the category of slightly aspirated. By that time, this occurrence still had not been considered for BP VOT voiceless stops, since they had only been categorized as unaspirated. The researchers analyzed the production of thirty-five BP native speakers, from South and South-east of Brazil. The results presented were divided into aspirated and unaspirated productions. It was reported that for the velar and alveolar stops, the aspirated production was more frequent, whereas for the bilabial stop, aspiration occurred in approximately 50% of the samples. The mean presented by Alves et al. (2008) was 40.67 ms for the aspirated voiceless /t/; while for non-aspirated, it was 18.28 ms. The results presented by Alves et al. (2008) evidence the presence of long-lag VOT as a variant of the voiceless stop in Brazilian Portuguese (Alves et al., 2008).

Another research that analyzed the production of stop consonants in the BP was Alves (2015). The study involved five female participants from Santa Catarina, who were around 21 and 26 years old. As can be seen in Table 5, the results showed that the VOT of the velar stop /k/ had a longer duration, if compared to previous studies. According to Alves (2015) the voiceless stops were included in the short-lag category. The voiceless stops /p/ and /t/ had values in the range of 0-35 ms, thus being classified as non-aspirated stops. The velar /k/ had values higher than 35 ms, from those values, 67% presented VOT in the range of 35-55 ms, being then considered as slightly aspirated stops. And 33% in the range of 55-95 ms, being classified as aspirated (Alves, 2015). The mean VOT values for the voiceless stop /t/ was 20 ms, and for the voiced stop /d/ -87 ms. The full results obtained by Alves et al. (2015) are presented in Appendix B, which displays the results of the VOT values in initial position.

Melo et al. (2017) conducted a study with adults and children in Santa Maria -RS. The segments analyzed were the alveolar stops /t/ and /d/, and the velar stops /k/ and /g/. The adult participants were 19 to 44 years old, while the children were 4 to 8 years old, all of them with typical development of speaking, i.e., those whose progress and learning are in line with what

is expected for their age. According to the author, through the study, it was possible to observe the voicing contrast and the distinction of the four pairs: /t/ - /k/, /t/ - /g/, /d/ -/g/ and /d/ - /k/; no relevant difference was observed (Melo et al., 2017). The mean VOT for the voiceless stop /t/ was 16.96 ms for adults and 20.47 ms for children; whereas for the voiced stop /d/, it was -114.85 ms for adults and -108.78 ms for children.

Appendix B provides a table that summarizes the VOT values and means of the BP studies mentioned in this section.

## 2.5 POLISH VOICE ONSET TIME

Similarly to Portuguese, the Polish language also exhibit short-lag VOT for voiceless stops, /p/, /t/ and /k/, with values around 30 ms, although, some studies presented results in which the velar segment /k/ can exceed 50 ms. In Polish there is an opposition between a voiceless unaspirated category and a voiced unaspirated category, i.e., the /p/, /t/ and /k/ short voicing lag is contrasted with voicing lead in initial /b/, /d/ and /g/ (Keating, 1980; Keating, 1984; Keating; Mikoś; Ganong III, 1981).

Some studies involving VOT for Polish monolinguals are reference for this parameter. Kopcyński (1977) collected relevant VOT values for Polish, and his work involving this parameter was one of the first in Polish. He collected VOT values from L1 Polish and L2 English, living in Poland. In the present study, we use Kopcyński (1977)'s results as VOT reference. Table 6 has Kopcyński (1977)'s results for Polish VOT.

Table 6. Kopcyński's (1977) VOT values for Polish stops

| /p/ | /b/ | /t/ | /d/ | /k/ | /g/ |
|------|------|------|------|------|------|
| 37.5 | -78 | 33 | -72 | 49 | -61 |

Source: the author

Keating et al. (1981) collected data from five native Polish speakers; they were all monolinguals. In their research, real and unreal words were used; for the real, 42 disyllabic words were used. Keating et al. (1981) results corroborate the statement that Polish uses prevoicing for the voiced stops and short-lag VOT for the voiceless stops (Keating et al., 1981).

The VOT values presented by Keating et al (1981) is 27.9 ms for the voiceless stop /t/ and -89.9 ms for the voiced stop /d/.

Wrembel (2014) conducted research about voiceless stops /p/, /t/ and /k/ in stressed onset position, divided into two studies. The first one analyzed the production of VOT by multilingual speakers, L1 Polish, L2 English and L3 French. The second one involved speakers of L1 Polish, L2 English and L3 German. This study involved not only analysis of descriptive data, but also crosslinguistic influences. The results showed slightly higher VOT values for Polish multilingual speakers, if compared to monolingual speakers. Wrembel (2014)'s Study 1 presented a mean VOT of 33 ms for the voiceless stop /t/, while Study 2 had a mean VOT of 34 ms for the same stop consonant.

Sypiańska (2021) conducted research among speakers of Polish L1, senior learners of English L2. The main objective of the study was to analyze the VOT production in English, but it was also collected the mean values in their Polish. Since they were native Polish speakers, we consider important to bring these results. The researcher also included a control group, formed by native Polish speakers without any contact with English, with mean age of 68.8 years old. For the voiceless stop /t/, the bilingual group produced a mean VOT of 29.5 ms; while the Polish monolingual speakers had a mean VOT of 25.5 ms. For the voiced stop /d/, the bilingual group presented a mean VOT of -112.3 ms, whereas the Polish monolingual speakers produced a mean VOT of -119.9 ms.

The VOT values for voiced stops presented by Sypiańska's (2021) are higher than those presented by Keeting et al. (1981) and Kopcyński (1977); whereas the unvoiced stops did not have considerable difference. Sypiańska's (2021) concludes that the L2 English showed signs of L1 drift by the L1 Polish senior learners of L2 English, i.e., the Polish speakers have prolonged VOT when producing L1 Polish (Sypiańska, 2021).

It is worth to mention that we have not found any research involving VOT by Brazilian heritage speakers of Polish. A summary of the mean VOT from all the Polish studies mentioned in this section is available in Appendix C.

The Polish results show that the Polish voiceless stops are produced having slightly positive VOT values, but still a little higher than VOT of the studies presented by BP, mostly the velar stop /k/.

2.6 ENGLISH VOICE ONSET TIME IN L2 CONTEXT

In case of English spoken by BP speakers, a common aspect in English pronunciation is not to produce aspiration of voiceless stops in contexts where aspiration is expected, as well as the production of long-lag voiced stops. A study conducted by Prestes (2013) investigated the VOT production of voiced stops by BP speakers, comparing them to native English speakers. The study compared data from three groups, one composed by American English native speakers; another by BP speakers, intermediate English learners; and the last one, by BP speakers with high level of English proficiency. The results presented by Prestes (2013) corroborated previous research, showing that native BP speakers produce English stop consonants in onset position having a lower level of aspiration than a native English speaker.

Table 7: Prestes' (2013) reference VOT values for Portuguese voiced stops in ms

|  | /b/ | /d/ | /g/ |
|---|---|---|---|
| **Intermediate speakers** | -127 | -121 | -120 |
| **Advanced speakers** | -122 | -105 | -100 |
| **Native speakers** | -102 | -90 | -84 |

Source: the author

These values show that the velar stop had lower results in the three circumstances. The native participants presented lower VOT mean for the three stops, if compared to the BP speakers. Prestes (2013)'s VOT result for the voiced stop /d/ serve as a base for reference of BP bilingual speakers in the present study.

França (2011) conducted a study with 22 participants, 6 male and 16 female. The researcher analyzed the production of the voiceless /p/, /t/ and /k/ in terms of VOT in BP and in English spoken by those speakers of BP as the native language. The results evidenced that the participants had higher VOT values in English than in BP, even though the values did not achieve values considered target for English. The values in English and Portuguese are in Table 8.

Table 8: França's (2011) reference VOT values for voiceless stops in ms

|  | /p/ | /t/ | /k/ |
|---|---|---|---|
| **English** | 27.43 | 45.83 | 58.61 |
| **Portuguese** | 19.56 | 21.66 | 47.20 |

Source: the author

In the present study, França's (2011) results are used as reference for the voiceless stop /t/ in the case of BP bilingual speakers.

Data from English spoken by native Polish speakers is provided by Wojtkowiak (2022). The research included four different groups. Group 1 is important for our comparison, because the participants chosen by Wojtkowiak were English major students, whose main objective was to have a native-like pronunciation, their motivation was due to their future work, reported the participants. There were twenty participants, 19-20 years old, and they all were university students, categorized as B2-level[7] of English. The study with these participants was longitudinal. The numbers presented in Table 9 show the three recording sessions (T1, T2 and T3). They were recorded during the Polish academic year: T1 in October, during the first two weeks of the start of the academic year. T2, after one semester of the academic year, in February. And T3, in June, by the end of the academic year. Group 2 consisted of 15 participants with age 20-21, native Polish speakers, and English L2, having B2/C1 level. Group 3 was formed by 15 participants, native Polish speakers, L2 English C1/C2 level. Group 4 was composed by quasi-monolinguals, because it would be difficult to find a group of people who had never been taught any other language, being true monolinguals. Group 4 served as a control group and it was divided into two groups. This division was done because one group read Polish word list, while the other read a sentence list. It has been verified that the VOT of Polish stops is slightly longer in word lists than when produced in longer prosodic constituents (Wojtkowiak, 2022). As the objective of this subsection is discussing the VOT production in English as L2, in Table 9 we do not present the results found for Polish-quasi monolinguals.

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[7] Reference of level of proficiency: the Common European Framework of References for Languages.

Table 9: Mean VOT, in (ms), of the voiced and unvoiced stop consonants in English spoken by Polish speakers in Wojtkowiak (2022)

|  |  | /p/ | /b/ | /t/ | /d/ | /k/ | /g/ |
|---|---|---|---|---|---|---|---|
|  |  |  |  |  |  |  |  |
|  | T1 | 46.87 | -92.54 | 58.56 | -84.96 | 73.04 | -86.37 |
| Group 1 | T2 | 50.36 | -88.23 | 61.80 | -81.87 | 77.35 | -81.17 |
|  | T3 | 49.95 | -85.63 | 60.95 | -82.02 | 73.26 | -80.17 |
| Group 2 |  | 66.53 | -83.91 | 74.90 | -84.09 | 89.07 | -68.02 |
| Group 3 |  | 67.94 | -91.76 | 70.08 | -91.32 | 60.23 | -82.13 |

Source: the author

We can see from the VOT values presented in Table 9 that, even though, the Polish participants from group 1 aspired to have English native-like pronunciation, they did not achieve native VOT values, taking into account the English VOT values presented in section 2.4. In the present study, we use the mean VOT of group 1 as refence for Polish bilingual speakers, i.e., for the voiceless stop /t/ 60.93 ms and for the voiced stop /d/ -82.95 ms.

English learners in Poland struggle to produce long lag values for English stops consonants at such a high level, and for this reason, according to Rojczyk (2010), English pronunciation coursebooks for Polish learners encourage students to produce a puff of air ensuing plosion (Rojczyk, 2010). The objective of this procedure is to induce students to produce higher VOT values and, thus, achieve a pronunciation closer to a native speaker's one. The studies involving the production of stop consonants in English by Polish speakers shows that they usually produce intermediate values, higher than in Polish language, but not like a native English speaker.

Besides that, Rojczyk and Porzuczek (2012) state that native Polish speakers commonly produce English /b/, /d/ and /g/ with negative VOT values, and pronounce the English /p/, /t/ and /k/ with short positive VOT values, i.e., without aspiration. The /p/, /t/ and /k/ produced without aspiration may cause misperception, most of all by native English speakers, because they will be perceived as /b/, /d/ and /g/. (Rojczyk; Porzuczek, 2012). Furthermore, Kopcyński's (1977) studies, showed many examples of English /b/, /d/ and /g/ being perceived as voiceless by Polish speakers.

The following spectrogram (Figure 3), presented by Rojczy and Porzuczek (2012), shows the difference in the production of the Polish word *ten* ('this') and the English word 'ten'. The difference consists in the lack of aspiration of the plosive /t/ in Polish, VOT value of 18 ms, while in English, the plosive /t/ is strongly aspirated, VOT value of 198 ms.

Figure 3: Measurements of VOT for /t/ Polish *ten* (18 ms) and English 'ten' (198 ms)
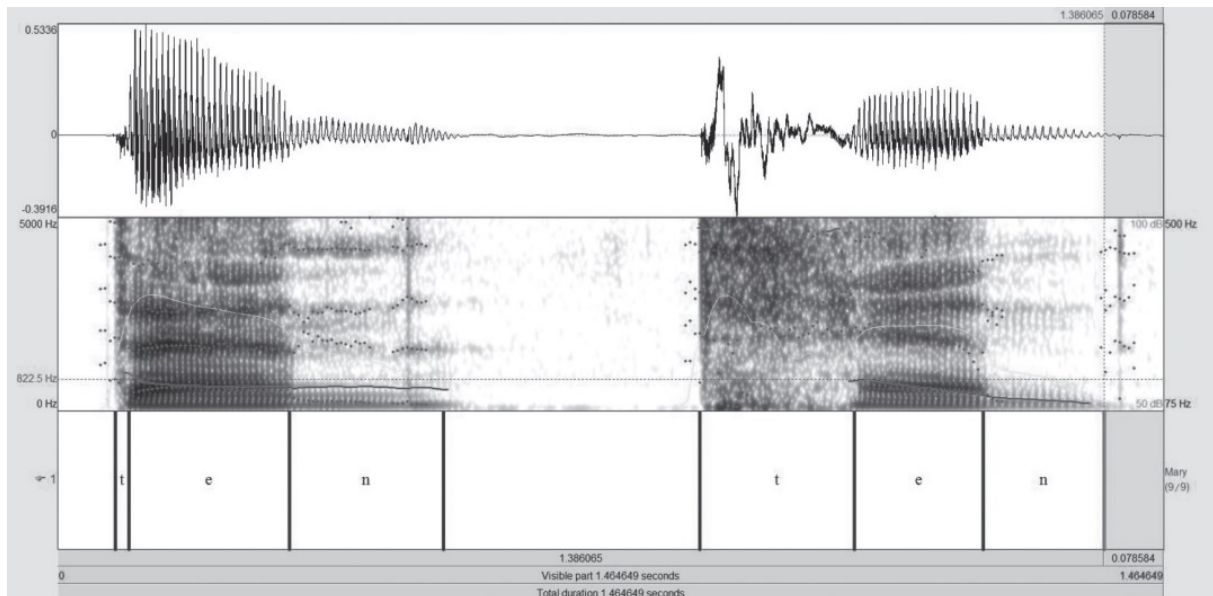


Source: (Rojczyk; Porzuczek, 2012, p.102).

Thus, these numbers solidify what previous literature points out, (e.g. Flege; Eefting, 1987), native speakers of a language that has different VOT categories than that of his/her L2 tend to produce the VOT in the target language with values between the L1 and L2.

To conclude this discussion, Figure 4 presents the commonest ways voiced stops /b/, /d/ and /g/; and voiceless stops /p/, /t/ and /k/ are produced in Portuguese, Polish and English.

Figure 4: Commonest production of stop consonants in Portuguese, Polish and English
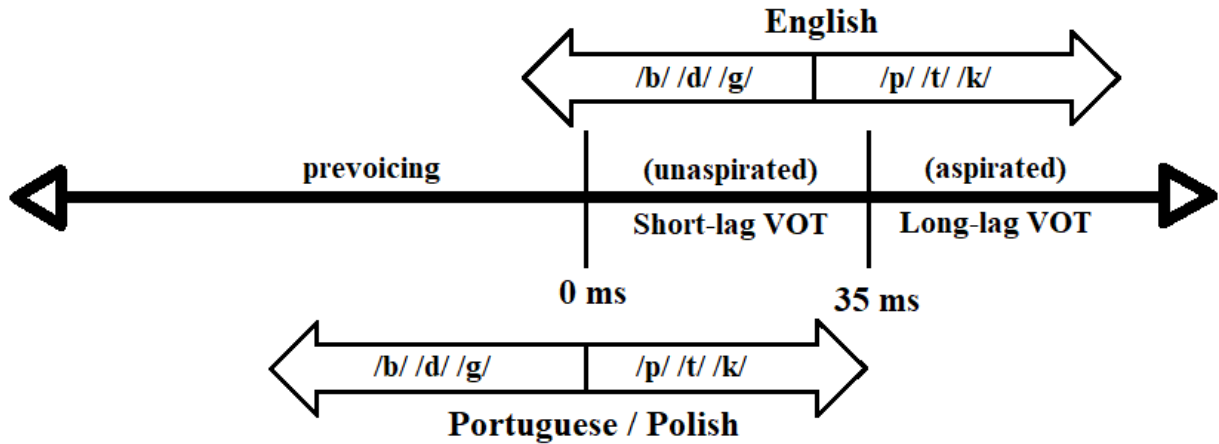


Source: the author

## 2.7 CROSSLINGUISTIC PHONETIC-PHONOLOGICAL INFLUENCES

Crosslinguistic influence refers to the different manners that one language can affect another in a bilingual or multilingual speaker (Jarvis; Pavlenko, 2008). There are several factors that can cause crosslinguistic influences, such as language universals, typological distance between L1 and L2, level of proficiency etc. (Jarvis; Pavlenko, 2008). Kujałowicz (2005) defines crosslinguistic influence as the interaction of all of the languages that a person masters in his/her mind. On the other hand, in case of phonetic-phonological influences, Jarvis and Pavlenko (2008) define crosslinguistic influences as, "the ways in which a person's knowledge of the sound system of one language can affect that person's perception and production of speech sounds in another language" (Jarvis; Pavlenko, 2008, p. 62).

Crosslinguistic influence in the area of phonology has often been seen as negative transfer. This assumption is due to the fact that L1 may influence significantly accent, stress, rhythm and intonation in L2 (Ringbom, 2007). However, we can take into account that L2 sounds are commonly perceived through L1, and even if L1 affects these items, its role in L2 transfer can be considered positive in individual speech sounds. This is because depending on the typological distance from L1 to L2 or L3, the similarity features of the languages can be easier for the production of some sounds, i.e., when the system of the first and second language have the same origin, e.g., Slavic, Germanic or Romance languages. According to Ringbom (2007), phonological L1 transfer is shown as negative because the positive side of phonological

transfer has not been studied deeply. We could also add that the negative reputation of phonological transfer also reveals a view of L2 acquisition that aims to equate bilingual or multilingual speakers to monolingual speakers, which we do not see as the best approach to language description.

L3 acquisition can be influenced by the L1 or L2. Peukert (2015) states that there are four circumstances for L3 transfer in initial stages: no transfer, absolute L1 transfer, absolute L2, and L1 and L2 transfer. There are different reasons for one or another occurrence, such as age of acquisition and proficiency.

Having highlighted the acoustic feature of the target segments in the three languages that will be analyzed in this study, we move on to present the method.

# 3 METHOD

This is a quasi-experimental, quantitative and exploratory research. The purpose of it is to investigate the production of the stops /t/ and /d/ by Brazilian multilingual speakers, Portuguese-Polish-English, descendants of Polish immigrants. The target sounds were embedded in carrier words that were recorded, and the target segments were acoustically and auditorily analyzed with the help of the Praat program. Thus, this research fits as a lab-based study. Since this is a cross-sectional study, the data collection consisted of a single section for each participant.

Section 3.1 provides information about the participants. Section 3.2, describes the instruments for data collection, namely, Pre-screening questionnaire, which was used to get information about the linguistic profile of the participants (3.2.1); Background questionnaire (3.2.2); Production tests (3.2.3), designed to collect speech samples from the participants; Audio editing (3.2.4) and the consent form (3.2.5). Section 3.3 presents the procedures for data collection and analysis. The analysis of the production was conducted with the Praat program.

## 3.1 PARTICIPANTS

The participants of this study were recruited by e-mail. The researcher contacted Polish descendants and adopted the strategy of snowball sampling, which "involves a 'chain reaction,' whereby the researcher identifies a few people who meet the criteria of a particular study and then asks these participants to identify appropriate further members of the population." (Mackey; Gass, 2012, p. 81). A total of twelve participants were interviewed and, five of them, fulfilled the criteria[8] to participate in the study, namely: Participant 1 (P1), Participant 2 (P2), Participant 3 (P3), Participant 4 (P4) and Participant 5 (P5).

Five Brazilian speakers of Portuguese, Polish and English participated in this study. One was male and four were female. Their age, reported in the background questionnaire, ranged from 22 to 59 years old. Detailed information about the participants' background is displayed in section 4.1.

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[8] The criteria are described in section - *3.2.1 Pre-screening questionnaire.*

The participants did not receive any financial compensation for their participation in the study. All recruited participants were originally from the region of the North of *Santa Catarina* and South of *Paraná* states, living close to their border, around the cities of *Porto União – SC* and *União da Vitória – PR*. Figure 5 shows the location of both cities.

Figure 5: Location of *União da Vitória – PR* and *Porto União – SC* cities



Source: the author

## 3.2 INSTRUMENTS FOR DATA COLLECTION

Three instruments were used to gather data: an invitation by email, followed by a pre-screening questionnaire; a background questionnaire; and a production test, developed on PowerPoint. The data were collected in a hybrid format. The first two instruments were sent by e-mail and completed by the participants; while the PowerPoint presentation was used in meetings in person, in order to have a better quality for the audio recordings. In this section, we provide information and details about each one of those materials, and also the consent form, signed by the participants.

Table 10 summarizes the three procedures and their respective objectives in this research.

Table 10: Research instruments and objectives

| Instrument | Objective |
|---|---|
| Invitation and pre-screening questionnaire | To find potential participants, and verify if their profile fitted the study. |
| Background questionnaire | To collect data about participants' background, i.e., age, history language learning and use. |
| Production test | To obtain speech samples by recording participants' reading aloud the target words. |

Source: the author

### 3.2.1 Pre-screening questionnaire

The first step was to send an email to potential participants. After those who gave positive answers to take part in the study, a new email was sent, containing the pre-screening questionnaire. This instrument consisted of questions to ensure that they had the requirements to participate. The questions were sent in Portuguese and can be seen in Appendix D. Following, we present their translation:

1. What is your first, second and third language?
2. From 0 to 5, what level of proficiency do you attribute to your first language?
3. From 0 to 5, what level of proficiency do you attribute to your second language?
4. From 0 to 5, what level of proficiency do you attribute to your third language?
5. Where do you currently reside?
6. What is your place and date of birth?

These questions allowed us to verify if the potential participants met the criteria to take part in this research. We verified their age, since we wanted to recruit participants who were 18 years old or older. We also verified their languages and had an initial estimate about their proficiency, and if they were not living abroad. The invitation emphasized that we were recruiting Polish descendants to take part in the study. The invitation was written in Portuguese, and is available in appendix E. Those potential participants whose answers in the pre-screening

questionnaire did not show they fulfilled the requirements for this study were, then, not invited to continue to the next procedures of the research.

### 3.2.2 Background questionnaire

For getting information about the participants' background and linguistic experiences, a questionnaire was developed on Google Forms. The main inspiration for this questionnaire was the instrument developed by Scholl and Finger (2013), but some adaptations were made to fit the research context. The questions were divided into four sections: the first part had the objective of obtain personal information, such as age and place of birth; the second one asked participants about their language history; the third section had questions concerning the use of the languages; and the fourth one asked about their proficiency in their L1, L2 and L3. The questionnaire was written in Portuguese because, since the participants of this study were living in Brazil and had access to formal education in Portuguese, it was expected that they had a better command of this language when it comes to reading. The full questionnaire and information about how it was adapted are available in Appendix F[9].

### 3.2.3 The production tests

For the production of the target sounds, three slide presentations were created on PowerPoint. The first one contained Portuguese words; the second brought Polish words; and the last one had English words. There were five words containing the target sound /t/ and five words containing the target sound /d/ in each of the three presentations. It was expected that some participants could not have a good level of reading proficiency for one or more languages. For this reason, we tried to select high-frequency, simple words for the data collection. For English, the target words were all monosyllabic, whereas for Portuguese and Polish, we used disyllabic words. We did not use monosyllabic words in these two languages because both, Polish and Brazilian Portuguese languages have a limited number of monosyllables, different from English.

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[9] The linguistic questionnaire is based on Scholl and Finger (2013).

When collecting data using a word list, Menn (2017) suggests that there should be two distractors for every target word. Thus, for this research we adopted this approach. Each slide presentation had ten distractors and each target word was repeated three times, in order to ensure that the target sounds were produced at least once. Table 11 summarizes the target words and distractors used for the three production tests.

Table 11 – Summary of target words and distractors for the production tests

|  | Portuguese | Polish | English |
|---|---|---|---|
| **Target words** | 5 disyllabic words with /t/ 5 disyllabic words with /d/ | 5 disyllabic words with /t/ 5 disyllabic words with /d/ | 5 monosyllabic words with /t/ 5 monosyllabic words with /d/ |
| **Distracters** | 10 words | 10 words | 10 words |
| **Repetitions** | 3 | 3 | 3 |
| **Total target** | 30 | 30 | 30 |
| **Total distractors** | 30 | 30 | 30 |

Source: the author

The data were obtained through the five target words in each of the three languages. The target sounds of each language will be analyzed in terms of VOT duration, an acoustic measurement that captures the time relationship between the release of a stop closure and the initiation of phonation for a following vowel (Di Paolo; Yaeger-Dror, 2011).

Table 12 has the target words and the distractors that were used for each production test. The tests are also available in Appendix G. A total of 90 target words were produced by each participant, 30 for each language.

Table 12: Target words and distractors for data collection

| | Target words | |
|---|---|---|
| | **/d/** | **/t/** |
| PORTUGUESE | DADO (dice) | TAPA (slap) |
| | DELA (her) | TETO (roof) |

| | DAVA (gave) | TAÇA (cup) |
|---|---|---|
| | DEDO (finger) | TESE (thesis) |
| | DOCE (sweet) | TOPA (agree) |
| POLISH | DAWA (give) | TATA (dad) |
| | DOBRY (good) | TOWAR (commodity) |
| | DESER (dessert) | TERAZ (ago) |
| | DATA (date) | TAKI (such) |
| | DESKA (board) | TEKSTY (text) |
| ENGLISH | DAD | TAP |
| | DOLL | TOP |
| | DOOR | TALL |
| | DOG | TALK |
| | DESK | TEST |
| Distractors | | |
| PORTUGUESE | CASA (house) | NOVE (nine) |
| | LÁPIS (pencil) | RIO (river) |
| | CAMA (bed | BAIXO (low) |
| | PIANO (piano) | MATA (woods) |
| | RUA (street) | LAMA (mud) |
| | SOL (sun) | NEVE (snow) |
| | BOCA (mouth) | MAÇA (apple) |
| | HOJE (today) | ALGA (seaweed) |
| | FACA (knife) | MEL (honey) |
| | PAPEL (paper) | FLOR (flower) |
| POLISH | PIES (dog) | KOT (cat) |
| | FLAGA (flag) | LEWO (left) |
| | LAT (year) | PARA (pair) |
| | LIS (fox) | GUMA (rubber) |
| | WODA (water) | SMAK (flavor) |
| | NOGA (leg) | UFNY (confident) |
| | MATKA (mother) | WINO (wine) |

|  | ILE (how much)<br>KOLOR (color)<br>BLISKO (near) | ZERO (zero)<br>GAZETA (newspaper)<br>NOS (nose) |
|---|---|---|
| ENGLISH | NAME | PAPER |
|  | BLUE | WEEK |
|  | FIVE | SONG |
|  | SCHOOL | CAR |
|  | PLANE | RED |
|  | BOOK | OVER |
|  | MUSIC | MONEY |
|  | THIS | THINK |
|  | THERE | THUNDER |
|  | THOUGH | THOUGHT |

Source: the author

The three PowerPoint presentations were similarly developed, each slide included one word that was programmed to appear automatically on the computer screen after every four seconds. This amount of time for word transition was used by Manfé (2019) to collect speech data using isolated words as well. The participants were asked to read every word that appeared on the slides aloud, while being audio recorded. There were some motives for making the PowerPoint presentation separately into three files. The main reason is because the speakers need time to code-switch before starting to record the tokens of each language. Thus, each division of the presentation, i.e., Portuguese, Polish and English, began by presenting to the speaker a paragraph in the language being tested, to help the speakers switch into the target language before they started recording the target sounds. Since there was the possibility that some participants would not have a good command of reading, whether in Polish or in English; then, it was used a voice reader[10] recording online for the three languages for the initial paragraph. The use of different files, together with the audio recording of each initial paragraph to present each test hopefully provided the participants with enough time to minimize

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[10] The voice reader is a technological resource, available online on Google. It consists of a browser extension that provides a variety of native voices to read words, phrases or texts, which can be recorded and downloaded.

crosslinguistic influences. The target words and distractors were presented in different randomized orders. Figure 6 presents a screenshot of the initial English production test. The short text used before each of the three production tests and the full test productions are available in Appendix H.

Figure 6: Screenshot of the first 8 slides of the English production test
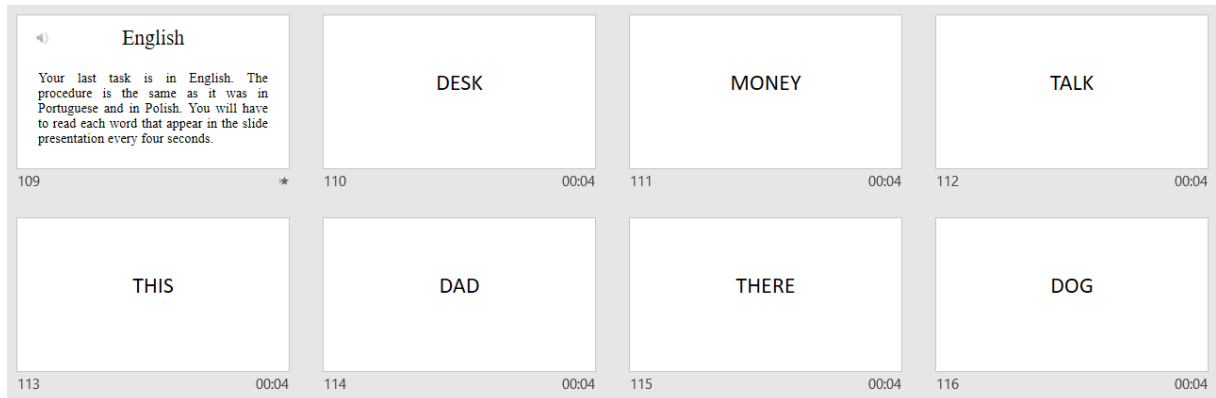


Source: the author

In order to obtain the word frequency, three corpora were used, one for each of the three languages. A corpus provides the number of times a word is used in a wide range of genres. For English, it was used the Corpus of Contemporary American English (COCA) (Davies, 2008). COCA is the most recent and balanced corpus of English, divided into five genres: spoken, fiction, popular magazines, newspapers, and academic journals for each year and also miscellaneous (Davies, 2009).

For Portuguese, we used *Corpus do Português NOW* (CPN) (Davies; Ferreira, 2006). CPN is a corpus that includes four varieties of Portuguese: Brazil, Portugal, Mozambique and Angola. To the present study, we searched words for BP, since the participants are Brazilian. CPN has approximately 1.4 billion words from newspapers and magazines available on the internet between 2012 and 2019.

For Polish, it was used the National Corpus of Polish (NKJP – Narodowy Korpus Języka Polskiego), (Przepiórkowski, 2012). NKJP is the largest corpus of the Polish language, its diversity embraces literature, daily newspapers, specialized periodicals, journals, transcripts of conversations and internet texts (Wróblewska, 2020).

Table 13 displays the word frequency of the thirty tested words, in English from COCA; in BP from CPN; and in Polish from NKJP. For each language, we present a rank of frequency (RoF), which helped to stablish the frequency use of the words in the present study.

Table 13: Frequency of the tested words in English, Portuguese and Polish

| ENGLISH | | | PORTUGUESE | | | POLISH | | |
|---|---|---|---|---|---|---|---|---|
| Word | Frequency in COCA | RoF | Word | Frequency in CPN | RoF | Word | Frequency in NKJP | RoF |
| Dad | 144,004 | 4th | Dado | 64,885 | 1st | Dawa | 131 | 10th |
| Doll | 10,794 | 10th | Dela | 37,265 | 3rd | Dobry | 185,645 | 3rd |
| Door | 210,164 | 3rd | Dava | 19,925 | 6th | Deser | 4,337 | 8th |
| Dog | 98,847 | 6th | Dedo | 11,614 | 8th | Data | 29,728 | 5th |
| Desk | 42,700 | 7th | Doce | 26,832 | 4th | Deska | 3,152 | 9th |
| Tap | 16,095 | 9th | Tapa | 5,294 | 9th | Tata | 20,019 | 7th |
| Top | 260,566 | 2nd | Teto | 39,366 | 2nd | Towar | 26,809 | 6th |
| Tall | 39,616 | 8th | Taça | 18,498 | 7th | Teraz | 883,757 | 1st |
| Talk | 360,702 | 1st | Tese | 26,315 | 5th | Taki | 504,419 | 2nd |
| Test | 138,243 | 5th | Topa | 884 | 10th | Teksty | 44,481 | 4th |

Source: the author

The audio recordings were done with the following sound equipment: The hardware utilized was a computer DESKTOP-B62E1KB, Intel(R) Core (TM) i5-5200U CPU @ 2.20GHz 2.20 GHz. The microphone was a condenser, type Lapela New Live P3, 20 Hz – 20.000 Hz frequency. The software used was Praat version 6.2.14, which has the recording sound option, the used sampling rate was at 44100 Hz, mono, 16 bits.

**3.2.4 Consent Form**

The Consent Form (available in Appendix I) was presented to the selected participants. The document was shown before the data collection session, in order to ensure that the participants were aware of the procedures of the study and their rights as well. They were also

clearly communicated that the participation was voluntary and, thus, if they wished, they could quit the study at any time. Besides that, they were guaranteed that the researcher would take all precautions to preserve their anonymity and not disclose information about their identity.

Furthermore, before getting in touch with the participants, the project, the instruments and the Consent Form of the study were submitted to the *Comitê de Ética em Pesquisa com Seres Humanos (CEPSH/UFSC) da Universidade Federal de Santa Catarina.* The documents were approved under the protocol number CAAE: 67294423.5.0000.0121.

## 3.3 PROCEDURES FOR DATA COLLECTION

The data were collected during the first semester of 2023. The background questionnaire was answered according to the participant's availability. As for the production tests, each participant had to choose a day and time to meet with the researcher in order to complete the audio recording.

The data collection was obtained through the background questionnaire and the three production tests. Firstly, it was asked to the participants to answer the background questionnaire, that was sent by email for them to complete it individually. Therefore, each participant could take his/her time to answer it.

The last part of the data collection involved collecting speech data by administering the production tests, which were done individually and in face-to-face meetings scheduled according to the participants' availability. The participants were oriented to be as silent as possible while producing their recordings, in order to avoid any type of noise that could interfere with the quality of the recordings. For all recordings, the researcher tried to obtain data that is suitable for acoustic analysis in PRAAT. For good quality, all recordings should have a sample rate of 16kHz and 16 bits (Di Paolo; Yaeger-Dror, 2011).

The audios were recorded at *Universidade Estadual do Paraná (UNESPAR)*, located in the city of *União da Vitória - PR.* This procedure was done because all the participants lived close to it and they agreed to go over there to have their audio recorded. The university had a quiet room at *Colegiado de Letras Português/Inglês*, which used to be a computer lab. The room did not have any acoustic treatment. But echo or reverberation were not observed. The use of this room was formally requested through a letter (available in Appendix J) addressed to

the *Colegiado de Letras- Português/Inglês* of the university, and sent by email. The request was discussed in a meeting by the *Colegiado de Letras- Português/Inglês'* professors and a protocol was developed, authorizing the use of the room, with consensus of the general direction of the campus. The protocol is available in Appendix K.

The individual meetings were scheduled according to the participants' availability. But they were organized around 5pm to 7pm, as it allowed to avoid background noise, since it is usually a period of few people around the recording area. The first step of the meetings was to explain the procedures to the participants. They were also warned to avoid producing any kind of noise while recording the tests. Each participant was instructed to sit in front of the computer and, then, to pin the microphone on his/her clothes, taking care to be in a position of around 10 centimeters from the mouth and not touching the clothes.

The first production test presented was the Portuguese. The presentation had a short text in Portuguese, that was read by the Google voice reader, and followed by the participant. Right after that, the recorder was turned on and the participant was presented with the Portuguese words in the slide presentation. After the presentation was over, the recorder was turned off and the speech sample was saved as a .wav file.

The participants were allowed to have a five-minute break before starting the next production text, which was Polish. The same procedure was done for the Polish production test. The participants were sitting in front of the computer with the microphone. The paragraph in Polish was displayed in the presentation slide, while being read by the Google voice reader and followed by the participant. Then, the recorder was turned on and each participant produced the Polish words. When the Polish test finished, the recorder was turned off and the file was saved as a .wav format.

The last production test was the English one. One more time the participant was allowed to have a break before starting the production test. Then, in front of the computer wearing the microphone and ready to start, the English paragraph was put in the slide presentation and the voice reader read it, while the participant was following it. Right after the recording equipment was activated and each participant produced the English test words. The speech samples were saved as a .wav file.

Thus, the order of the three Production tests was the following for every participant: Portuguese, Polish and English. In general, each participant took about fifteen minutes to

complete the three production tests. The procedure of saving the files in .wav format was important for them to be used in PRAAT for acoustic analysis later.

## 3.4 PROCEDURES FOR DATA ANALYSIS

Since there were two types of instruments for data collecting (production tests and questionnaire), the data analysis consisted of two parts. The first was concerning the questionnaire information to identify the participants' background. The characteristics analyzed are their age, language use, linguistic experience and level of schooling. The second part consisted of the analysis of the target sounds. The VOT values were annotated on text grids. The consonants were analyzed acoustically with the help of the Praat program. The property analyzed was the duration of the stops /t/ and /d/ in terms of Voice Onset Time (VOT). A quantitative analysis was conducted with the acoustic data taking into account the following variables.

Dependent variables:
1. VOT measures of stops /t/ and /d/ for the three languages.

Independent variables:
2. Self-reported level of proficiency of the participants for the three languages, obtained from the linguistic questionnaire;
3. Linguistic experience that affects the productions of /d/ and /t/ sounds;
4. Amount of L1, L2 and L3 use;
5. Age of L1, L2 and L3 acquisition;

### 3.4.1 Audio editing

For the audio editing, we used Audacity, which is a free software for digital audio recording and editions. For this study, the version 3.3.1 was used, for two objectives: normalizing amplitudes and removing background noises.

The first procedure was to remove background noises, and this was done on the following way: inside Audacity, one recording, saved in wav. file, was opened. Then, a sample of the noise to be removed was selected. The option "effects" was selected, then "remove noise" and "obtain noise profile". Next, the whole audio recording was selected, and the option "effects" was selected one more time, followed by the option "remove noise". Then, the audio quality was previewed, adjusting the option "noise reduction" in dB until the background noise was removed.

The second step was to normalize the amplitude. The procedure started by selecting the whole audio recording. Then the following options were selected "effects", "amplitude and comprehension", "amplitude". Next, the amplitude was adjusted in dB until before the audio started clipping, i.e., when the sound waves go above the top. It was inspected if all the audio recordings had similar amplitudes. It was also verified and ensured that those procedures did not affect any property of the sounds.

### 3.4.2 VOT measurement

The data analysis consisted of getting the VOT values, measuring, in milliseconds, the interval between the release of closure and start of voicing. Through the waveforms and spectrograms presented in Praat it is possible to obtain the VOT values for voiceless stops with short-lag VOT (unaspirated) and with long-lag VOT (aspirated). Similarly, Praat allows obtaining VOT values for the voiced stops, and when these stops are produced with prevoicing, VOT is presented with a minus (-) signal. Figure 7 and 8 demonstrate how VOT was measured, using BP words as examples.

Figure 7: BP word *teto,* voiceless stop /t/
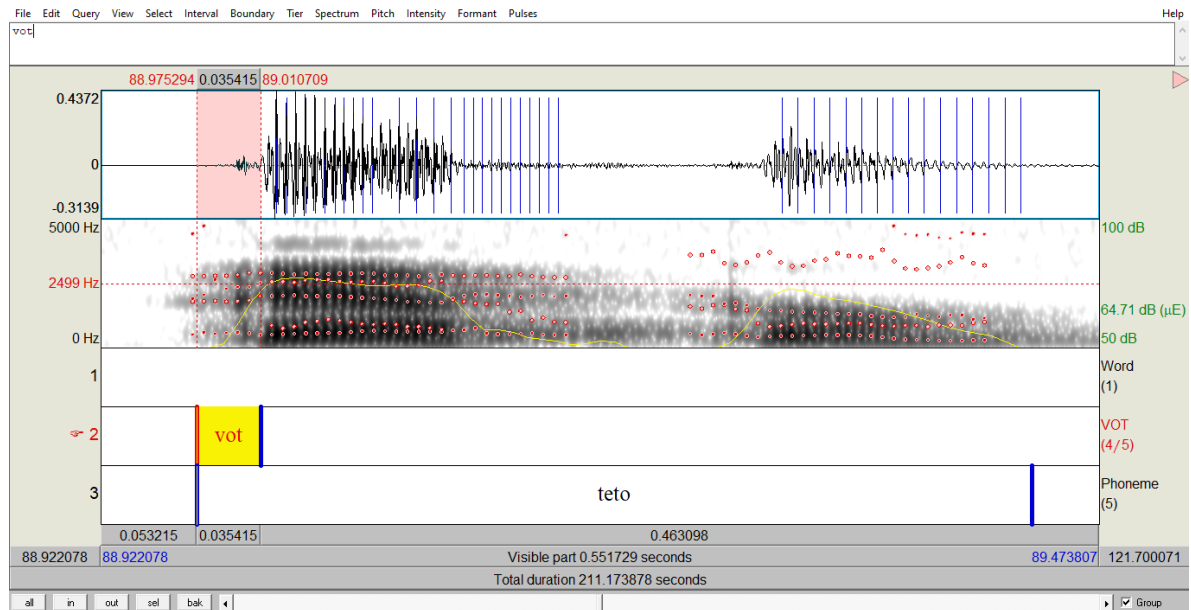


Source: the author

In Figure 7, we see the screenshot of Praat. The BP word *teto* was produced by P1 of this study. The VOT value of the voiceless /t/ is 35.41 ms.

Figure 8 has an example of the voiced stop /d/. It was produced by P1 as well, and it has a VOT value of -97.33 ms.

Figure 8: BP word dado, voiced stop /d/
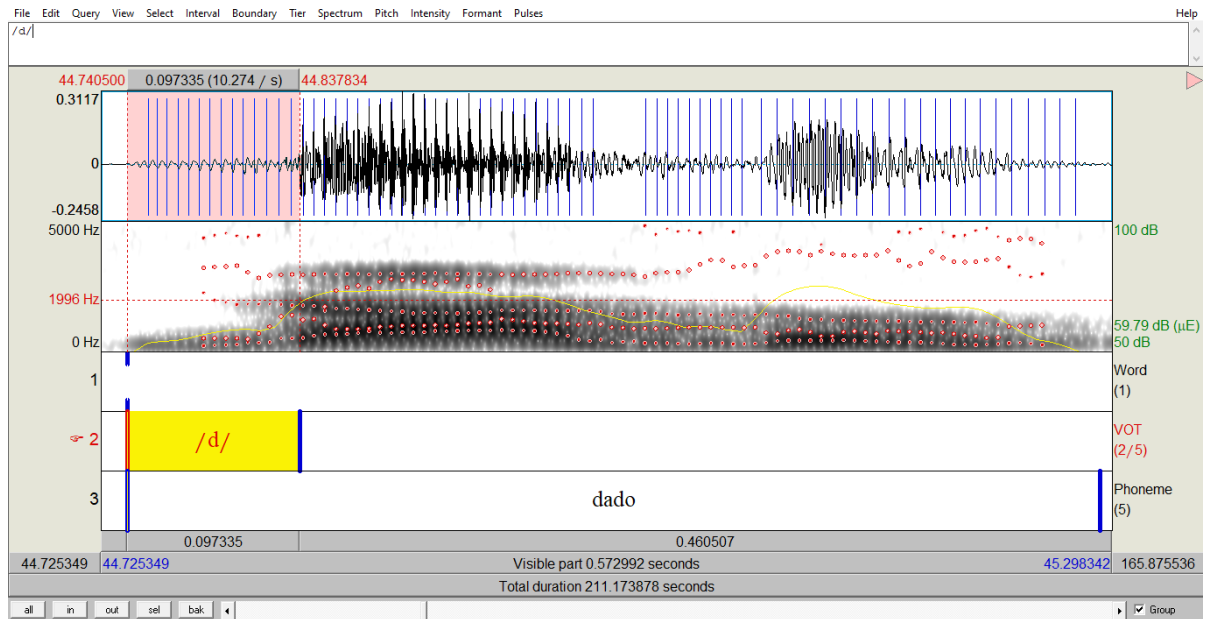


Source: the author

In the next chapter, we present the analysis and the discussion of the collected data. We present the results and mean, median, standard deviation (SD), maximum and minimum VOT for each participant, as well all the participants' mean. The focus of the analysis is the whole group of participants and also each individual, which is possible because the study examines data from a small number of participants.

**4 RESULTS AND DISCUSSION**

In this chapter, we present an analysis and a discussion of the collected data. In section 4.1, we start by presenting the information obtained through the linguistic background questionnaire (available in Appendix F). The discussion is presented individually, being subsection 4.1.1 for P1; subsection 4.1.2 for P2 and so on. In section 4.2, we present the VOT values obtained in this study.

4.1 PARTICIPANTS' BACKGROUND

There were five participants in this study, they all speakers of Brazilian-Portuguese, Polish and English. All the participants were originally from cities in North of *Santa Catarina* and South of *Paraná* region. This section describes participants' age, gender, education level and place of birth. We also present information about language use, history and proficiency of the participants. We display information for each participant in a different subsection.

**4.1.1 Participant 1**

Participant 1 (P1) was a Brazilian, born in *Paula Freitas – PR* city, female gender. By the time of the data collection, she was 59 years old, and she had an undergraduate level of education. P1 had English as her L2, and started learning it when she was eight, but started using English actively at age 18. P1 learnt English in school and in language courses. Polish language was the L3 of P1, she started learning it at the age 45 and started using it actively when she was 48 years old. When the data were collected, she had had direct contact with Polish for 14 years. P1 reported having learnt the Polish language in language courses and by herself. Table 14 describes P1's contributions from each activity for her English and Polish learning. The numbers correspond to a scale from zero to six. It is interesting to notice the different learning paths for English and Polish. P1 reports having learned English mostly from attending language courses, reding and listening to the radio or music. Conversely, Polish has been learned mostly from interaction with family, friends, reading and language courses.

Table 14: Participant 1's activities for English and Polish learning

|  | **English** | **Polish** |
|---|---|---|
| **Interaction with family** | 1 | 3 |
| **Interaction with friends** | 2 | 3 |
| **Reading** | 3 | 3 |
| **Television/ movies** | 1 | 0 |
| **Radio/ music** | 3 | 1 |
| **Internet** | 2 | 2 |
| **Language course** | 4 | 3 |

Source: the author

P1 reported always using Portuguese with her mother, relatives and friends; and at work, often for speaking, reading and writing. She reported that from her language use weekly, Portuguese takes 60% of the time, while the other languages are responsible for the last 40%.

P1 reported to use Portuguese for counting, doing calculations, taking notes, expressing anger and affection. Thus, Portuguese was the language P1 used the most.

P1 did not use Polish regularly with friends or relatives. But P1 reported that Polish occupies 30% of her language use during the week. P1 informed to watch TV/movies in Polish casually, but not regularly as in case of the other activities. Even though, P1 did not speak Polish every day, she practiced this skill every week. And she read and wrote in Polish every day.

In case of English, P1 informed not to use it regularly with friends or relatives. Her English use was the least compared to her other two languages, around 10% during the week. P1's use of English was daily only for listening to music, while for other activities it was sporadically used, i.e., even though, she did other tasks in English, they did not happen regularly. Thus, there were times she used English more, and times she used English less, casually. P1's weekly language use for the following tasks were as it follows on Table 15:

Table 15: Participant 1's use of languages

|  | **Portuguese** | **English** | **Polish** |
|---|---|---|---|
| **Watching TV/ movies** | Once a week | Sporadically | Sporadically |
| **Listening to music** | Every day | Every day | Every week |
| **Reading** | Daily | Sporadically | Every day |
| **Writing** | Daily | Sporadically | Every day |
| **Speaking** | Daily | Sporadically | Every week |

Source: the author

In her self-reported proficiency, P1 reported having a high level of proficiency for the four skills in her L1.

For Polish, P1 reported considering she had not achieved total fluency in yet. But by the time the data were collected, she attended a Polish course weekly, intending to achieve a higher level of proficiency.

P1 achieved fluency in English at age 18. Table 16 summarizes P1's level of proficiency in Portuguese, English and Polish. The numbers correspond to a self-rating scale ranging from zero to six.

Table 16: Participant 1's proficiency in Portuguese, English and Polish

|  | **Portuguese** | **English** | **Polish** |
|---|---|---|---|
| **Reading** | 6 | 5 | 4 |
| **Writing** | 6 | 5 | 5 |
| **Listening** | 6 | 4 | 4 |
| **Speaking** | 6 | 5 | 5 |

Source: the author

## 4.1.2 Participant 2

Participant 2 (P2) was born in the city of *Cruz Machado*, in the state of *Paraná,* and was male. P2 was 22 years old and had a High School level of education.

His L2 was Polish and he started learning it during his childhood, together with Portuguese, his L1. At the age 6, P2 used Polish actively and was fluent on it. He learnt Polish at home and in language courses.

English was P2's L3, he started learning it at age 15. At age 20 he started using English actively, as he became fluent on it. His English learning was by himself, at home and in language courses. Table 17 displays P2' activities for his L2 and L3 learning. The table shows that Polish was learned mostly from multiple sources, but mostly from a combination of interaction with the family, language course, internet, TV and radio/music contact. On the other hand, English learning emerged from language courses, reading, movies, radio/music and the internet.

Table 17: Participant 2's activities for English and Polish learning

|  | Polish | English |
|---|---|---|
| **Interaction with family** | 6 | 1 |
| **Interaction with friends** | 3 | 4 |
| **Reading** | 3 | 6 |
| **Television** | 4 | 3 |
| **Movies** | 2 | 5 |
| **Radio/ music** | 4 | 6 |
| **Internet** | 5 | 6 |
| **Language course** | 6 | 6 |

Source: the author

By the time the data were collected, P2 reported using his three languages: Portuguese for speaking with his mother, relatives and friends, and at work for reading, speaking and writing; Polish for speaking with his father, mother and other relatives; while English was used to speak with friends and read/write at work. During the week, P2 used Portuguese 90 per cent of the time; Polish 2% and English 8%. Table 18 displays P2's use of languages.

Table 18: Participant 2's use of languages in hours

|  | Portuguese | Polish | English |
|---|---|---|---|
| **Watching TV/ movies** | 4 | 0 | 3 |
| **Listening to music** | 1 | 1 | 20 |
| **Reading** | 6 | 1 | 6 |
| **Writing** | 8 | 1 | 2 |
| **Speaking** | 18 | 5 | 6 |

Source: the author

P2 used Portuguese for counting, calculating, taking notes, expressing anger and affection; Polish for counting, calculating and taking notes; and English for expressing anger and affection. Table 19 displays P2's self-reported proficiency in his three languages.

Table 19: Participant 2's proficiency in Portuguese, Polish and English

|  | Portuguese | Polish | English |
|---|---|---|---|
| **Reading** | 6 | 5 | 5 |
| **Writing** | 6 | 2 | 4 |
| **Listening** | 6 | 5 | 5 |
| **Speaking** | 6 | 4 | 5 |

Source: the author

## 4.1.3 Participant 3

When the data were collected, Participant 3 (P3) was 22 years old, female, born in the city of *Cruz Machado – PR*. She had an undergraduate level of education.

P3 had Portuguese as her L1, Polish as L2 and English as L3. She learnt Polish at home in her childhood, together with Portuguese and, thus, using Polish actively and becoming fluent on it by the age of three. P3 learnt English at school, starting when she was 11 years old and achieving fluency by the age of 16. Table 20 displays P3's activities for her L2 and L3 learning, the numbers correspond a scale from zero to six. We can observe that Polish learning comes mostly from interaction with family and friends, as well as contact with internet and the media.

On the other hand, English learning is mostly derived from interaction with friends, media, and reading.

Table 20: Participant 3's activities for English and Polish learning

|  | Polish | English |
|---|---|---|
| **Interaction with family** | 6 | 0 |
| **Interaction with friends** | 6 | 6 |
| **Reading** | 4 | 6 |
| **Television** | 6 | 6 |
| **Movies** | 6 | 6 |
| **Radio/ music** | 6 | 6 |
| **Internet** | 2 | 6 |
| **Language course** | 2 | 5 |

Source: the author

P3 used Portuguese for speaking to her mother, relatives, friends and at work. She used Polish for speaking to her mother and other relatives; and English for speaking to her friends and at work for reading, writing and speaking. She reported always speaking with her mother, relatives, and friends was always.

By the time the data were collected, P3 reported not using English; while she was using Portuguese around 80% of her language use weekly, and Polish 20%. For Portuguese, P3 did not estimate a number of hours spent in activities such as watching TV/films, listening to music, reading, writing and speaking. For Polish, she informed spending around two hours reading, one hour writing and one hour speaking. And she was not using English for any of the activities by that time. Table 21 displays P3 use of languages.

Table 21: Participant 3's use of languages in hours

|  | Polish | English |
|---|---|---|
| **Watching TV/ movies** | 0 | 0 |
| **Listening to music** | 0 | 0 |
| **Reading** | 2 | 0 |
| **Writing** | 1 | 0 |
| **Speaking** | 7 | 0 |

Source: the author

P3 informed to use her three languages for counting, taking notes, expressing anger and affection. And for doing calculation she used Portuguese and English. Table 22 displays P3's self-reported proficiency.

Table 22: Participant 3's proficiency in Portuguese, Polish and English

|  | Portuguese | Polish | English |
|---|---|---|---|
| **Reading** | 6 | 6 | 6 |
| **Writing** | 6 | 4 | 6 |
| **Listening** | 6 | 6 | 6 |
| **Speaking** | 6 | 6 | 6 |

Source: the author

### 4.1.4 Participant 4

Participant 4 (P4) was born in the city of *Mallet – PR,* thirty-two years old and female. P4's level of education was graduate. Her L1 was Portuguese, L2 English and Polish was her L3.

P4 learnt English at school and in language courses, starting at age ten and started using it actively at age 24. She learnt Polish in language courses and by herself; she started learning it at age 26 and started using it actively at age 31. Table 23 displays P4's activities for her L2 and L3 learning. English learning relied mostly on language course and internet use, as well as

media and reading. While Polish learning comes mostly from language courses and the media, P4 also reports using textbooks and exercises for self-learning.

Table 23: Participant 4's activities for English and Polish learning

|  | English | Polish |
|---|---|---|
| **Interaction with family** | 1 | 3 |
| **Interaction with friends** | 2 | 2 |
| **Reading** | 4 | 4 |
| **Television** | 3 | 2 |
| **Movies** | 4 | 3 |
| **Radio/ music** | 4 | 4 |
| **Internet** | 5 | 4 |
| **Language course** | 5 | 5 |
| **Textbooks and exercises** | 0 | 5 |

Source: the author

Table 24 displays P4's use of languages. By the time the data were collected, P4 informed not being using her L2 and L3 for the following activities, speaking to her mother, father, other relatives, friends and at work. She used Portuguese for them all. She reported using the L2 and the L3 mostly for listening to music. During the week, P4 used Portuguese around of 90 per cent of the time; Polish 5% and English 5%.

Table 24: Participant 4's use of languages in hours

|  | Portuguese | English | Polish |
|---|---|---|---|
| **Watching TV/ movies** | 20 | 2 | 2 |
| **Listening to music** | 2 | 10 | 15 |
| **Reading** | 30 | 2 | 2 |
| **Writing** | 5 | 1 | 2 |
| **Speaking** | 20 | 1 | 2 |

Source: the author

P4 reported taking notes in both three languages, Portuguese, English and Polish. Whereas for counting, doing calculations, expressing anger and affection, she only used Portuguese. Table 25 displays P4's self-reported proficiency.

Table 25: Participant 4's proficiency in Portuguese, English and Polish

|  | Portuguese | English | Polish |
|---|---|---|---|
| **Reading** | 6 | 4 | 3 |
| **Writing** | 6 | 4 | 2 |
| **Listening** | 6 | 3 | 3 |
| **Speaking** | 6 | 3 | 2 |

Source: the author

Finally, P4 informed having never taken a proficiency test, but she felt more confident in Portuguese for reading, writing, listening and speaking, which was due to the lack of opportunities for using her L2 and L3.

### 4.1.5 Participant 5

Participant 5 (P5) was born in the city of *Canoinhas,* state of *Santa Catarina.* By the time the data were collected, P5 was 26 years old, female, and had a graduate level of education. P5 had Portuguese as her L1, Polish as her L2 and English as L3.

P5 learnt Polish at home, starting when she was five years old and beginning to use it actively when she was eight. P5 informed not being totally fluent in Polish. English was learnt at school, language courses and by using the internet. She started learning her L3 when she was 12, using it actively at the age of 15 and becoming fluent at age 21. English learning came mostly from interacting with friends and internet and the media. Table 26 displays P5's activities for her L2 and L3 learning.

Table 26: Participant 5's activities for Polish and English learning

|  | Polish | English |
|---|---|---|
| Interaction with family | 6 | 5 |
| Interaction with friends | 5 | 6 |
| Reading | 2 | 4 |
| Television | 0 | 6 |
| Movies | 0 | 6 |
| Radio/ music | 5 | 6 |
| Internet | 6 | 6 |
| Language course | 0 | 5 |

Source: the author

P5 informed to use her L1 for speaking at work, to her mother, father, friends and other relatives, while Polish was used to speak with her mother, friends and other relatives. English was used at work, to speak to her friends and other relatives. P5 estimated to use Portuguese 60% of the time during the week, Polish 15% and English 25%. Table 27 displays P5's use of languages. We can see that Polish is mostly used for speaking and listening to music, while English is used more often to listen to music and watch TV/movies.

Table 27: Participant 5's use of languages in hours

|  | Portuguese | Polish | English |
|---|---|---|---|
| Watching TV/ movies | 4 | 0 | 3 |
| Listening to music | 5 | 2 | 4 |
| Reading | 2 | 0 | 1 |
| Writing | 2 | 0 | 1 |
| Speaking | 60 | 3 | 2 |

Source: the author

P5 informed she used her three languages for counting. And for doing calculations, taking notes, expressing anger and affection, she used Portuguese and English. Table 28 displays P5's self-reported proficiency.

Table 28: Participant 5's proficiency in Portuguese, English and Polish

|           | Portuguese | Polish | English |
|-----------|------------|--------|---------|
| Reading   | 6          | 2      | 6       |
| Writing   | 6          | 2      | 6       |
| Listening | 6          | 5      | 6       |
| Speaking  | 6          | 5      | 6       |

Source: the author

P5 reported feeling more confident in using the four skills, reading, writing, listening and speaking in her L1 and in English.

None of the participants reported having studied in bilingual schools. Table 29 summarizes demographic information about the participants.

Table 29: Participants' background

| Participant | Gender | Age | Education     | Place of birth     |
|-------------|--------|-----|---------------|--------------------|
| P1          | F      | 59  | Undergraduate | Paula Freitas – PR |
| P2          | M      | 22  | High school   | Cruz Machado – PR  |
| P3          | F      | 22  | Graduate      | Cruz Machado – PR  |
| P4          | F      | 32  | Graduate      | Mallet – PR        |
| P5          | F      | 26  | Graduate      | Canoinhas - SC     |

Source: the author

Table 30 summarizes the use of each language by each participant. The percentage numbers correspond to the amount of time the participants reported using each language per week. It is important to bear in mind that the participants' use were the ones reported when the data were collected, but some participants reported that there were times they used one language more than the others. Concerning the level of proficiency, the numbers represent the mean value in a scale from zero to six for writing, reading, speaking and listening, reported by each participant, e.g., P1 reported having the following level of proficiency in English: reading: 5; listening: 4; writing: 5; speaking: 5. Thus, the mean = 4.75.

Table 30: Participants' proficiency and languages' use

| Participant | Portuguese use | English use | Polish use | Portuguese fluency | English fluency | Polish fluency |
|---|---|---|---|---|---|---|
| P1 | 60% | 10% | 30% | 6 | 4.75 | 4.5 |
| P2 | 90% | 8% | 2% | 6 | 4.75 | 4 |
| P3 | 80% | 0% | 20% | 6 | 6 | 5.5 |
| P4 | 90% | 5% | 5% | 6 | 3.5 | 2.5 |
| P5 | 60% | 25% | 15% | 6 | 6 | 3.5 |

Source: the author

Regarding the participants' language use by the time of data collection, we can see that they all report using Portuguese more than 60% of the time, and that their use of Polish varies from 2% to 30%, while English varies from 0% to 25%. While they all reporting being fully fluent in Portuguese, their self-reported fluency for Polish varies from 2.5 to 5.5, and in English, from 3.5 to 6. Having presented the participants' background and language learning and use information, we now turn to the discussion of the acoustic data provided by them.

4.2 VOT DURATION OF THE STOPS

In this section, the objective is to present the results of the VOT values in English, Portuguese and Polish. We start by discussing the English results in subsection 4.2.1. We present the mean VOT values obtained from the whole data. Then, we show the results individually and also the VOT values by repetitions, since there were three repetitions of each word that contained the target sound. Finally, we discuss the level of aspiration. In subsection 4.2.2, we discuss the VOT values in Portuguese. We present the mean VOT values for each participant and the VOT mean from them all. Then, we investigate the mean VOT values by repetitions. In subsection 4.2.3, we discuss the Polish results. We start by presenting the mean VOT from the whole data, followed by the mean VOT individual values and, lastly, by repetition. In subsection 4.2.4, we discuss the data from the three languages, presenting the differences, similarities and patterns.

For comparison purposes, in the Review of Literature, we have selected studies of VOT values for reference from monolingual speakers of each language. The values in English are /t/ = 70 ms and /d/ = 5/-102 ms (Lisker; Abramson, 1964). In Portuguese, the references values are /t/ = 16.78 ms and /d/ = -99.20 ms (Klein, 1999). Finally, for Polish, the values are /t/ = 33 ms and /d/ = -72 ms (Kopczyński, 1977).

## 4.2.1 VOT duration in English

We start discussing the English VOT values by presenting the results individually. Table 31 displays the mean VOT values, the median and the Standard Deviation (SD) for each participant in English. The mean refers to the sum of all values divided by the total number of productions, thus representing a measure of central tendency. The median corresponds to the value in the middle of a data set, meaning that 50% of the data points have a value smaller or equal to the median and 50% of the data points have a value higher or equal to the median. Thus, the median divides the data in two halves. We opted for reporting both mean and median values because the means are likely to be impacted by outliers in the dataset. The standard deviation measures the average amount of variability in the dataset.

Table 31: Mean VOT values per participant in English

| | /d/ | | | /t/ | | |
|---|---|---|---|---|---|---|
| | **Mean** | **Median** | **SD** | **Mean** | **Median** | **SD** |
| **P1** | -83.53 | -91.82 | 24.13 | 45.92 | 46.3 | 4.59 |
| **P2** | -112.95 | -110 | 28.32 | 109.78 | 114.6 | 16.3 |
| **P3** | -88.11 | -83.39 | 15.39 | 46.82 | 45.66 | 5.27 |
| **P4** | -60.98 | -60.04 | 10.47 | 54.23 | 53.26 | 5.68 |
| **P5** | -121.99 | -116.48 | 19.72 | 60.97 | 59.07 | 8.96 |

Source: the author

The reference VOT value for the voicing stop /d/ used in the Review of Literature, section 2.3, is 5/-102 ms (Lisker; Abramson, 1964).

In the present study, the mean VOT value for /d/ from the five participants together was -93.51. This VOT value is within the range presented by Lisker and Abramson (1964), although there were individual mean VOT for the voiced stop /d/ higher than Lisker and Abramson's. The highest mean VOT value was from P5: -121.99 ms. while the lowest mean VOT result was from P4: -60.98 ms. To present the variability of each participant, Figure 9 displays the VOT results for /d/ individually.

Figure 9: Individual variability of the English VOT in ms for /d/ per participant
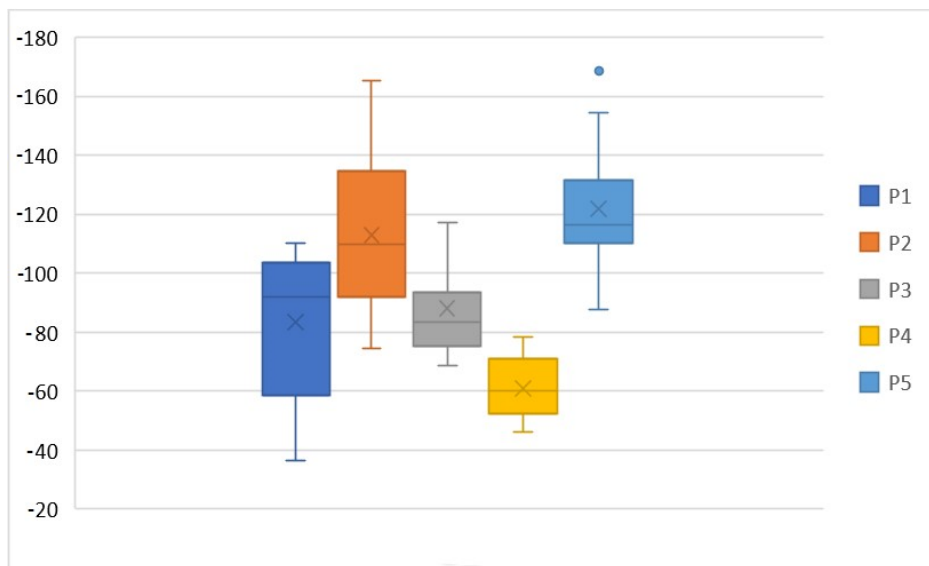


Source: the author

P1's VOT results went from -36.66 ms to -110.12 ms. P1 was the only participant whose median was higher than the mean for the English voiced stop /d/. We verify by P1's boxplot that the first quartile is in -58.45 ms and the third in -103.45 ms. Note that there is not a lot of variability with the upper quartile as there is for the first one. For the English values, P1 was the participant who present the further median from the mean, which indicates that the data are skewed. Whereas the mean was -83.53 ms, the median was -91.82 ms. Note that, even though P1 had a lower SD than P2, the mean and median VOT values from P2 were close. For the English voiced stop /d/, P1 was the participant who had the shortest VOT production: -36.66 ms.

P2 had the highest variability, since the highest VOT production was -165.48 ms and the lowest 74.42 ms. P2's boxplot indicates that the first quartile is in -91.86 ms and the third

quartile in -134.62 ms. The mean VOT produced by P2's was -112.95 ms. Thus, this participant produced VOT values above the ranges reported for native speakers of English, presented in the literature (Lisker; Abramson,1964).

P3's lowest VOT production was -68.83 ms and the highest -117.24 ms. P3's first quartile is in -75.34 ms and the third is in -93.5 ms. Unlike P1 and P2 VOT results for /d/, the VOT values produced by P3 present a smaller variability. This can be verified by the SD and the size of P3's boxplot, that is smaller than P1 and P2's boxplots.

From all the participants, P4 was the one who had the lowest VOT mean, -60.98. Furthermore, P4 was the one with the smallest variability for the English voiced stop /d/. P4 highest VOT production was -78.58 ms and the lowest -46.27 ms. P4's first quartile is in -52.57 ms and the third in -70.9 ms.

P5 was the only participant who produced an outlier VOT value for the English voiced stop /d/: -168.71 ms. Besides that, P5's productions went from -87.57 ms to -154.5 ms. P5's first quartile is in -110.22 ms and the third -131.67 ms. P5 was the participant with the highest VOT mean for /d/.

Concerning the voiceless stop /t/, retaking the bibliographic research in the Review of Literature, section 2.3, the VOT values presented in English is: 70 ms (Lisker; Abramson, 1964).

In the present study, the mean from the five participants together was 63.54 ms. This value is within the ranges reported for native speakers of English and it is a value considered high if compared to other studies that report English VOT data produced by Brazilian speakers, (e.g., 45.83 ms (França, 2011) for L1 BP speakers).

Figure 10 displays a boxplot for individual variability of the voiceless /t/. The objective is to observe the outlier VOT values and the data variability.

Figure 10: Individual variability of the English VOT in ms for /t/ per participant
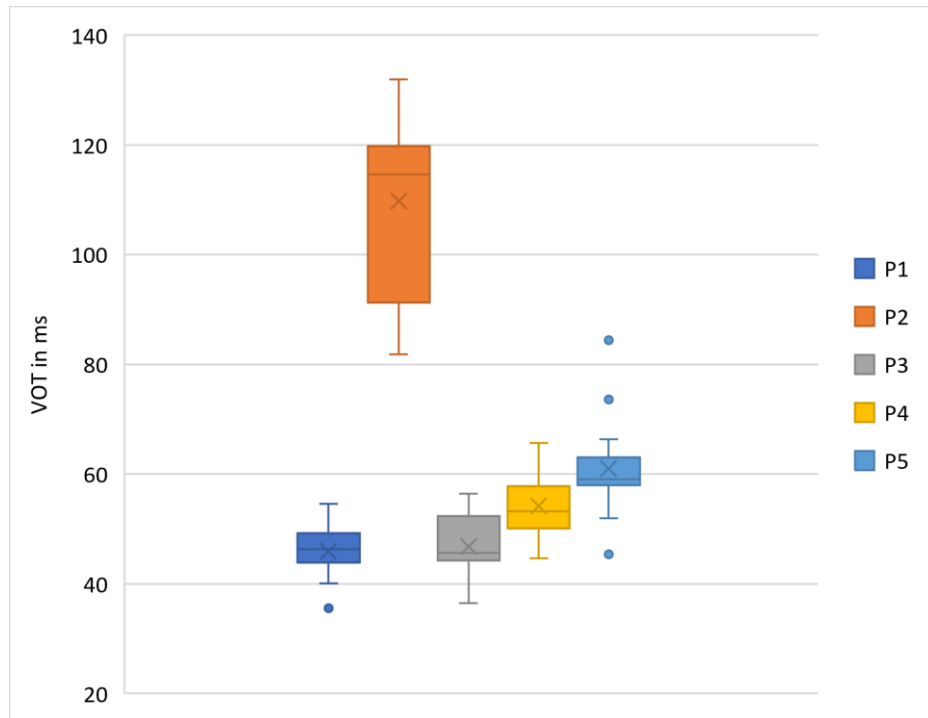


Source: the author

Looking at Figure 10, we see that the highest VOT value for P1 was 54.54 ms; while the lowest value was 35.53, this being an outlier value, because it is a value outside the average of the other VOT productions. Except for the 35.53 ms production, P1's production varied from 40.12 to 54.54.

P2 had the highest VOT values. P2's highest production was 131.95 ms, which indicates a high level of aspiration. The lowest production from P2 was 81.82 ms, not an outlier value. The results show that P2 was the participant who had the highest mean VOT value for the voiceless /t/, as well as the SD. The mean VOT for P2, if compared to the other participants, was considerably higher.

The VOT results from P3 varied from 36.51 ms to 56.38 ms. The variability was not huge, the SD was 5.27 and there was not any outlier value. P3's mean VOT for the voiceless /t/ was 46.82 ms, the lowest mean after P1, who had 45.92 ms. P1 and P3's mean VOT values were close to França (2011)'s VOT reference: 45.83 ms for Brazilian speakers of English.

P4's VOT results were higher than P3's, but they were the participants who had the smallest variability, given the fact that both did not present any outlier value and a narrow range

of VOT values. P1 had a lower SD than P3 and P4, but presented an outlier value. P4's VOT results went from 44.51 ms to 65.69 ms. P4's mean VOT was 54.23 ms.

P5 was the participant with the most variability; there were three outlier productions: two high VOT values: 84.37 ms and 73.6 ms; and one low VOT value: 45.39 ms. Besides those three VOT productions, the others from P5 went from 51.9 ms to 66.34 ms. P5's mean VOT for the voiceless /t/ was 60.97 ms. This value was the second highest mean, only lower than P2's mean, who presented a high level of aspiration.

Now, we discuss the English VOT mean by repetition. Considering the unpredictability of the productions, the repetition view helps us to see the variability and possible patterns. The words containing the target sounds /t/ and /d/ were repeated three times by each participant. Thus, we calculated the mean of the first, second and third repetition for each participant and the mean of the five participants together.

We start the discussion by presenting the mean VOT results for the voiced stop /d/. Figure 11 displays the VOT mean for the stop /d/ from each participant by repetition. The dotted lines correspond to the individual productions and the solid line represents the mean of the five participants. The y-axis (vertical line) represents the duration of the VOT in ms. The x-axis (horizontal line) is divided into three columns: the first (1st) stands for the mean VOT from the five words together that contained the voiced stop /d/, repeated at first time; the second (2nd) represents the mean VOT of the second production; and the third (3rd) stands for the mean VOT of the third repetition of the five words together.

Figure 11: English /d/ VOT mean by repetition
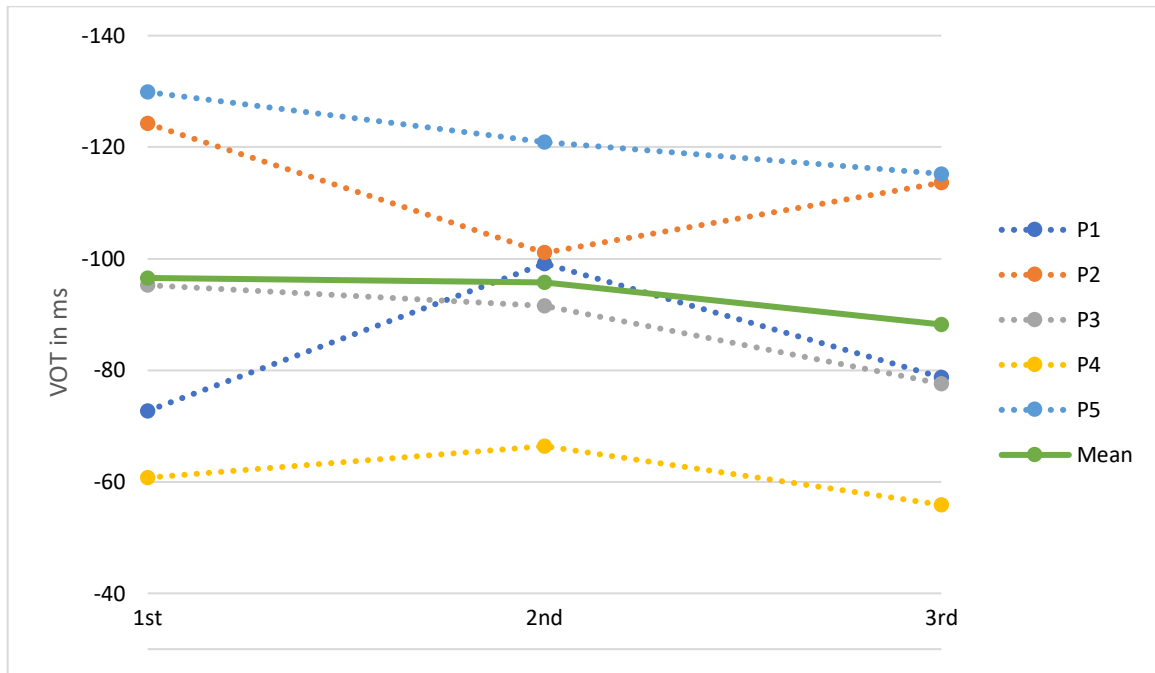


Source: the author

Figure 11 shows that there are different patterns, with most participants varying a lot. The only participants that produced similar patterns were P3 and P5. Both had their highest production at first repetition: P3 = -95.25 ms; P5 = -129.88 ms. Their second repetition was lower than the first one: P3 = -91.49 ms; P5 -120.90. And their third repetition had the lowest mean: P3 = -77.59 ms; P5 = -115.21 ms. For the voiced stop /d/, P5 was the participant who presents the highest VOT means. P3's VOT values were the closest to the mean of the whole group.

P1 and P4 were the participants whose VOT means increased in the second repetition. P1 had the highest variation (first repetition = -72.72 ms; second repetition = -99.12 ms), whereas P4 had -60.69 ms at first repetition and -66.39 in the second one. P1 and P4's third repetition shows a decrease, while P1 decreased to a mean between the first and second repetition, P4's third mean was the lowest of the three repetitions.

P2's first repetition was the second highest mean: -124.20 ms. Furthermore, P2 had the highest decrease, as the second repetition was -101.06 ms. All the participants had a decrease in the last repetition, the only exception was P2, who had an increase in the third repetition. The highest VOT mean of the group was the first repetition. The group's mean in the second

repetition had a very slight decrease, and the group's third repetition had a subtle decrease as well.

Now, we discuss the VOT values for the voiceless stop /t/. Figure 12, the displays the VOT in ms in the y-axis and, in the x-axis, the mean VOT of the first, second and third repetition. The graph displays the three productions of the voiceless stop /t/ for each participant and the mean of the five participants together.

Figure 12: English /t/ VOT mean by repetition
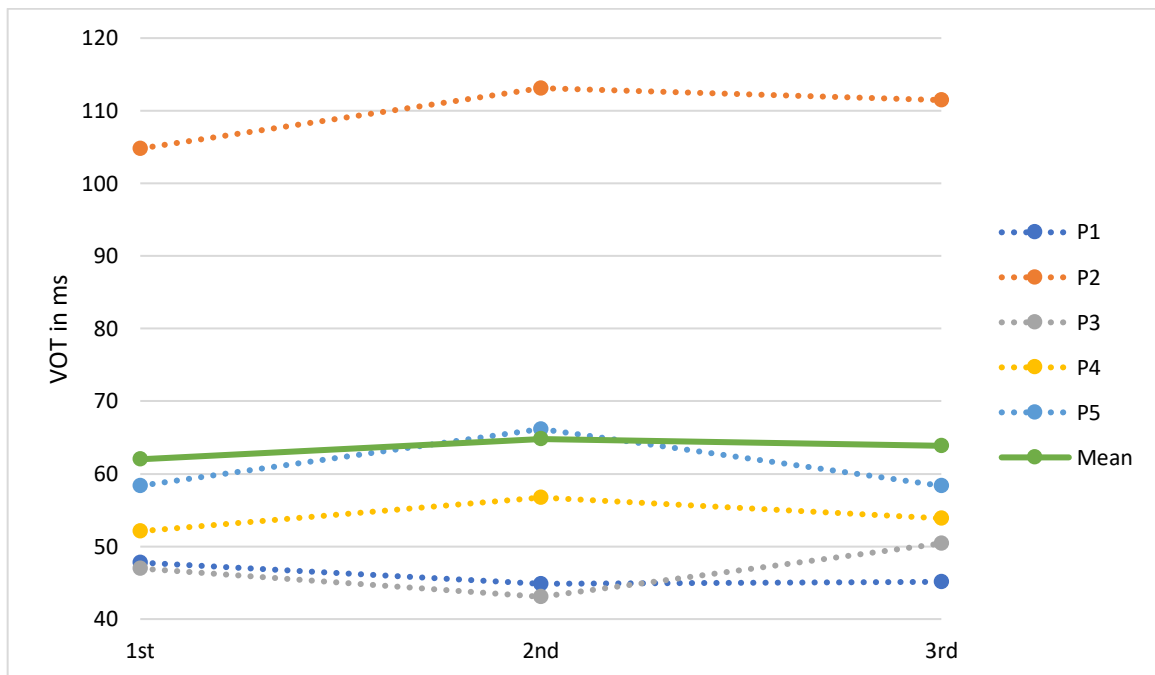


Source: the author

Figure 12 compares the three repetitions of the words containing the English /t/ for each participant. The mean VOT value is displayed in a solid green line, to allow comparing the individual results with the group average performance. Clearly P2 has a different performance, presenting higher VOT values than the other participants in the three repetitions. All participants display little variation when the three repetitions are compared. Three participants (P2, P5, and P4) start with low VOT values in the 1st repetition, show an increase in the VOT values of the 2nd repetition, and either maintain the VOT value in the 3rd repetition (P2 and P4) or go back to the VOT value of the 1st repetition (P5). On the other hand, two participants (P1 and P3) start with slightly higher VOT values in the 1st repetition, than show a slight

decrease in the 2nd repetition, but go in a different direction in the 3rd repetition (P3 shows a slight increase and P1, a slight decrease. The little individual variation of the participants occurred to the whole group, too: first repetition = 62 ms; second repetition = 64.79 ms; and third repetition = 63.84 ms.

Concerning the level of aspiration, the VOT results in English did not present any /t/ produced as unaspirated (Cho; Ladefoged, 1999) (cf. Table 3). Three of the participants (P1, P3 and P4) had most of their productions classified as slightly aspirated. One participant (P5) produced most of the tokens as aspirated and one participant produced most of the tokens as highly aspirated (P2). Table 32 displays the number of tokens produced as unaspirated, slightly aspirated, aspirated or highly aspirated stop.

Table 32: Number of tokens and percentages for English /t/ produced as unaspirated, slightly aspirated, aspirated or highly aspirated by each participant

|  | Unaspirated | | Slightly aspirated | | Aspirated | | Highly aspirated | |
|---|---|---|---|---|---|---|---|---|
|  | N | % | N | % | N | % | N | % |
| **P1** | 0 | 0 | 15 | 100 | 0 | 0 | 0 | 0 |
| **P2** | 0 | 0 | 0 | 0 | 4 | 26.66 | 11 | 73.33 |
| **P3** | 0 | 0 | 14 | 93.33 | 1 | 6.66 | 0 | 0 |
| **P4** | 0 | 0 | 9 | 60 | 6 | 40 | 0 | 0 |
| **P5** | 0 | 0 | 2 | 13.33 | 13 | 86.66 | 0 | 0 |

Source: the author

The "N" in Table 32 stands for Number. Having presented the VOT means, medians and standard deviations in English, we move on to present the values obtained for Portuguese.

**4.2.2 VOT duration in Portuguese**

In this subsection, we present the VOT values obtained in Portuguese. As well as it was discussed for the English results, we start the analysis of the Portuguese data by presenting the results individually. The reference VOT values for Portuguese /d/ is -99.20 ms and for /t/ is

16.78 ms (Klein, 1999). Table 33 displays the mean VOT values, the median and the Standard Deviation (SD) of each participant in Portuguese.

Table 33: Mean VOT values per participant in Portuguese

|  | /d/ | | | | /t/ | | |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | **Mean** | **Median** | **SD** | | **Mean** | **Median** | **SD** |
| **P1** | -124.95 | -125.12 | 25.61 | | 45.80 | 46.49 | 5.37 |
| **P2** | -127.93 | -123.12 | 19.44 | | 60.23 | 60.95 | 6.37 |
| **P3** | -109.82 | -107.94 | 19.08 | | 57.43 | 56.23 | 9.23 |
| **P4** | -89.11 | -91.51 | 16.76 | | 60.68 | 59.34 | 5.93 |
| **P5** | -113.84 | -115.07 | 22.84 | | 58.72 | 58.85 | 4.41 |

Source: the author

The mean VOT of the whole group for the Portuguese voiced stop /d/ was -113.13 ms. This mean VOT value was higher than the mean VOT value produced in English: -93.51 ms. Furthermore, it was a higher mean VOT than the one presented in the Review of Literature: -99.20 ms (Klein, 1999). In relation to the variability, we verify that, similarly to the English VOT values, the Portuguese also showed a huge variability. Figure 13 displays a boxplot of the Portuguese /d/ VOT values individually.

Figure 13: Individual variability of the Portuguese VOT in ms for /d/ per participant
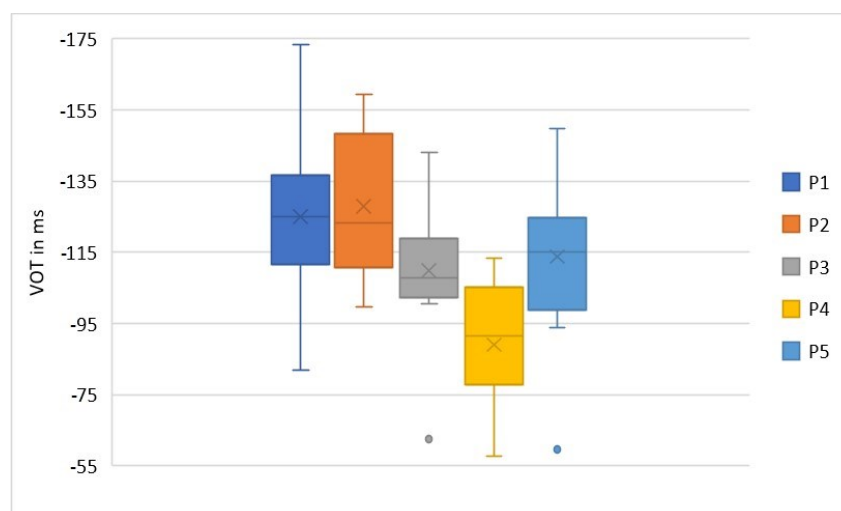


Source: the author

Figure 13 shows that P1 had the VOT productions with the highest variability, but there was no outlier value. P1's lowest VOT production was -81.90 ms and the highest was -173.44 ms. The first and third quartile show that most of P1's VOT productions were from -111.52 ms and -136.56 ms. Furthermore, P1 had three VOT productions lower than -111.52 ms and three higher than -136.56 ms, which caused a huge variability, as shown by the high standard deviation values obtained in the data for this participant (see Table 32). P1's mean VOT was -124.95 ms, the second highest in this study.

The highest mean VOT was from P2, who produced a mean VOT of -127.93 ms. P1 and P2 means are considered high if compared to reference values from other studies. However, P2 had a lower variability. P2 VOT values were from -99.66 ms to -159.33 ms.

From the results that had a mean VOT above Klein's (1999) reference for the voiced /d/: -99.20 ms, P3 was the participant who had the closest mean VOT: -109.82 ms. P3's VOT values went from -100.58 ms to -143.02 ms, and there was also an outlier value: -62.59 ms.

In this study, P4 was the participant who produced the lowest mean VOT for the BP voiced stop /d/. And was the only participant who produced a mean VOT lower than Klein's (1999) reference, having a mean VOT of -89.11 ms. P4 was also the participant with the lowest variability, SD = 16.76. P4 did not produce any outlier VOT value, with productions ranging from -57.71 ms to -113.28 ms.

P5 had only less variability than P1, having a SD of 22.84. The mean VOT of P5 was -113.84 ms. P5 produced an outlier value: -59.63 ms, while the other productions ranged from -93.98 ms to -149.64 ms.

Having seen the VOT values individually and looking at Figure 14, we note that, for the BP voiced stop /d/, P1, P2, P3 and P5 had more similar productions, while P4 had lower mean, median and standard deviation.

We now start discussing the BP voiceless /t/ by presenting a boxplot that contains the production of each participant. The productions of the present study had higher VOT values than the average reported by Klein (1999), which was 16.78 ms. Figure 14 displays the individual productions of the BP voiceless /t/.

Figure 14: Individual variability of the Portuguese VOT in ms for /t/ per participant
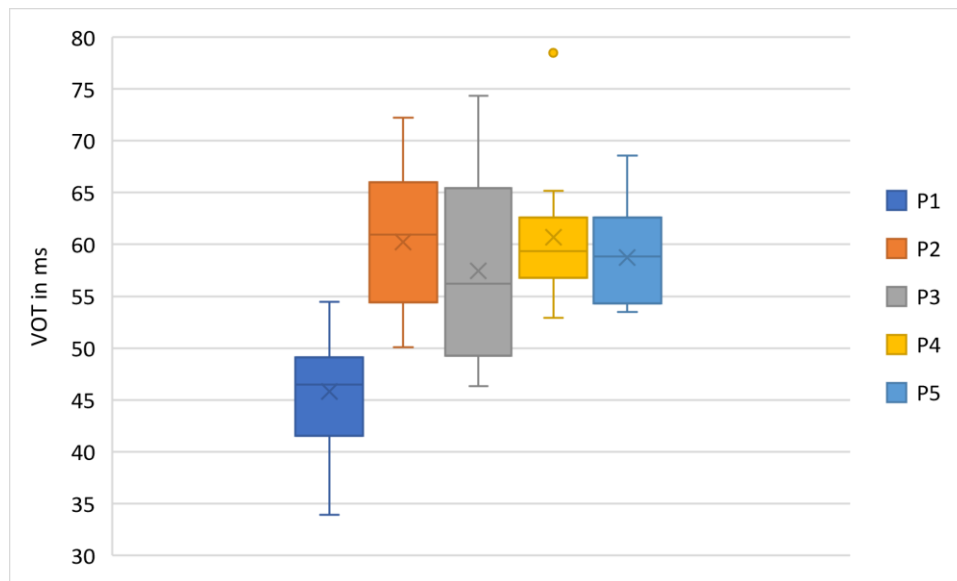


Source: the author

The BP voiceless /t/ VOT productions were similar for four participants (P2, P3, P4 and P5). Their VOT productions did not present a huge variability, being P3 the participant who had the highest variability with productions varying from 46.30 ms to 74.32 ms. P4 was the only participant who produced an outlier VOT value for the BP voiceless /t/ = 78.48 ms, while the rest of P4's VOT productions went from 52.92 ms to 65.18 ms.

P1 was the participant who produced the lowest VOT values, being the closest to Klein (1999)'s reference. P1's productions varied from 33.91 ms to 54.48 ms. P1's VOT productions for the BP voiceless stop /t/ were very similar to the productions in English, being the mean in English: 45.92 ms; and in BP: 45.80 ms.

P2 was the participant who had the highest variation concerning the VOT of the voiceless stop /t/ in BP in relation to the English one, whereas in BP it was 60.23 ms; in English it was 109.78 ms.

For the voiceless stop /t/, P3 and P4 were participants who produced longer VOT values in BP than in English. P5 had more variability in English than in Portuguese, producing VOT from 45,39 ms to 84.37 ms; whereas in BP the productions went from 53.50 ms to 68.56 ms. However, P5's VOT mean in BP and English were not far; BP = 58.72 ms and English = 60.97 ms.

Having presented the VOT values individually, we move on to discuss the BP VOT mean by repetition. As well as in English, the words containing the target sounds /t/ and /d/ were repeated three times by each participant. Thus, we present the mean VOT of the first, second and third repetition of each participant and the VOT mean of the five participants together.

First, we discuss the mean VOT results of the BP voiced stop /d/. In Figure 15, we display the VOT mean of the stop /d/ from each participant by repetition. The dotted lines correspond to each participant's productions and the solid line represents the mean of the five participants together.

Figure 15: Portuguese /d/ VOT mean by repetition
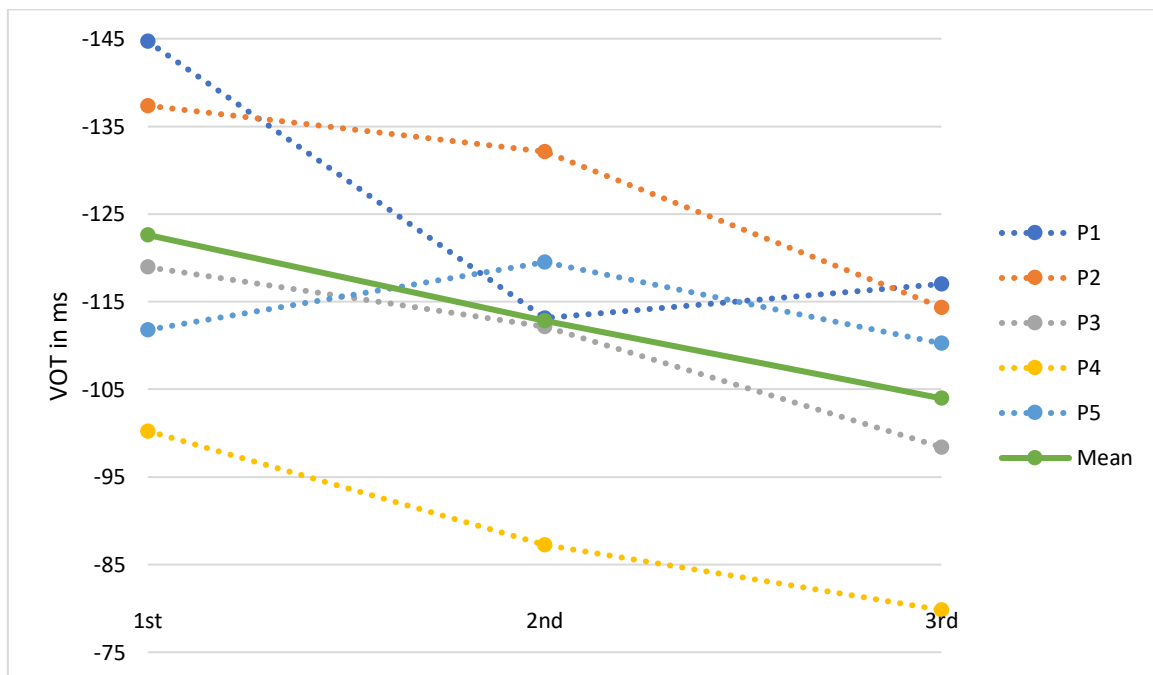


Source: the author

Figure 15 shows that the BP voiced /d/ had less variation than the English one. There were three participants (P2, P3 and P4) who produced the VOT in a similar pattern. Both of them produced their highest VOT productions in the first repetition, producing lower values in the second repetition, and having their lowest productions in the third one. P3 was the only participant who produced this same pattern in BP and in English. P3's productions were the

closest to the mean of the five participants together in BP. For the voiced stop /d/, P4 had the lowest productions in the three repetitions.

In relation to the three repetitions, P1 was the one who produced the highest variability, having a SD of 17.20. While P5 was the one who presented the lowest variability, SD = 4.96. P1 had the highest VOT production at the first repetition and the lowest in the second one, while P5's highest was the second repetition, and the lowest the third one.

Now, we present the VOT mean values by repetition for the BP voiceless stop /t/. Figure 16 displays the values for each participant (dotted lines) and the mean of the five participants together (solid line).

Figure 16: Portuguese /t/ VOT mean by repetition
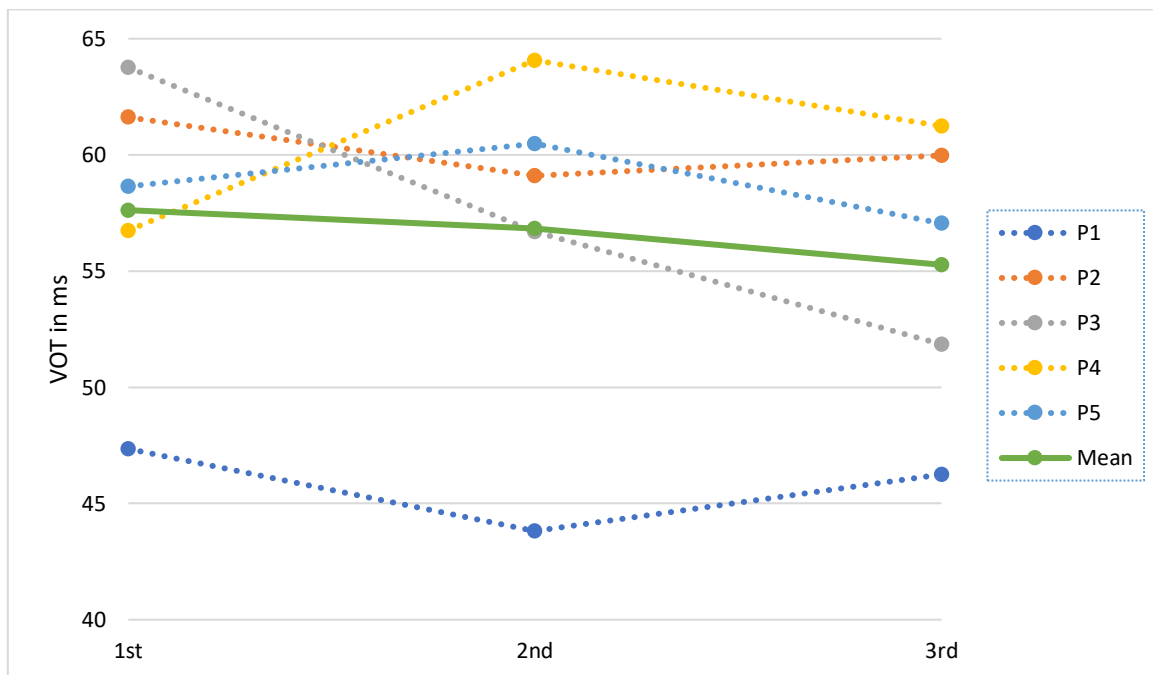


Source: the author

Figure 16 shows a similar pattern in relation to P1 and P2, being the first repetition the highest VOT productions for the BP voiceless stop /t/, then producing a little decrease in the second repetition, being this the lowest VOT of the three repetitions, and having a slight increase in the third repetition. However, P2's variation was very small in the three repetitions.

P3 produced the highest VOT in the first repetition. Then, decreased in the second repetition and, again, decreased in the third one. P3 was the participant with the highest variability for the BP voiceless stop /t/.

P4 and P5's production followed a similar pattern. Their first productions were lower than their second one. And in their third repetition, they had a small decrease. P4 and P5's highest productions were the second repetition. P4's lowest VOT was in the first repetition, while P5's lowest was the third one.

Table 34 displays the number of tokens produced as unaspirated, slightly aspirated, aspirated or highly aspirated stop for BP. The BP VOT results from the present study revealed a higher level of aspiration for the voiceless stop /t/ than the results presented in the literature (Klein, 1999). However, in general, there was a lower level of aspiration in Portuguese than in English (cf. Table 31). While the English voiceless stop /t/ was produced 11 times as highly aspirated, 24 as aspirated, 40 times as slightly aspirated and never as unaspirated, in Portuguese, there was one unaspirated production, 31 slightly aspirated, 43 aspirated and no highly aspirated production. Two of the participants (P3 and P4) had more aspiration in Portuguese than in English, having most of their BP productions classified as aspirated, while most of the English productions were classified as slightly aspirated. The other three participants had a lower level of aspiration in BP than in English. P1 was the participant who had the most similar level of aspiration in BP and English; while for English, all P1's productions were classified as slightly aspirated, in BP P1 produced one token as unaspirated and 14 as slightly aspirated. P2 was the participant who had the highest aspiration level in English, whereas in BP, P2's productions had less aspiration. P2 produced highly aspirated voiceless stop /t/ 11 times and four times as aspirated for the English tokens, whereas in BP, there were ten productions classified as aspirated and five as slightly aspirated. P5 produced most of the tokens as aspirated in both English and BP. However, in BP there were four slightly aspirated productions and eleven aspirated, while for English, there were 13 aspirated and 2 slightly aspirated.

Table 34: Number of tokens and percentages for BP /t/ produced as unaspirated, slightly aspirated, aspirated or highly aspirated by each participant

|  | Unaspirated | | Slightly aspirated | | Aspirated | | Highly aspirated | |
|---|---|---|---|---|---|---|---|---|
|  | N | % | N | % | N | % | N | % |
| **P1** | 1 | 6.66 | 14 | 93.33 | 0 | 0 | 0 | 0 |
| **P2** | 0 | 0 | 5 | 33.33 | 10 | 66.66 | 0 | 0 |
| **P3** | 0 | 0 | 7 | 46.66 | 8 | 53.33 | 0 | 0 |
| **P4** | 0 | 0 | 1 | 6.66 | 14 | 93.33 | 0 | 0 |
| **P5** | 0 | 0 | 4 | 26.66 | 11 | 73.33 | 0 | 0 |

Source: the author

Having presented and discussed the BP results, we move on to present the results for the Polish voiceless /t/ and voiced /d/.

### 4.2.3 VOT duration in Polish

In this section, we present and discuss the VOT results for Polish, following the same pattern of the preceding sections. First, we present the Polish results individually. The VOT reference values for Polish are /t/ = 33 ms and /d/ = -72 ms (Kopczyński, 1977). Table 35 displays the mean VOT values, the median and the Standard Deviation (SD) of each participant in Polish.

Table 35: Mean VOT values per participant in Polish

|  | /d/ | | | | /t/ | | |
|---|---|---|---|---|---|---|---|
|  | **Mean** | **Median** | **SD** | | **Mean** | **Median** | **SD** |
| **P1** | -75.43 | -72.84 | 28.88 | | 54.29 | 56.48 | 6.98 |
| **P2** | -128.48 | -125.52 | 21.82 | | 71.11 | 69.49 | 7.02 |
| **P3** | -93.48 | -95.04 | 11.28 | | 53.90 | 53.04 | 9.90 |
| **P4** | -75.71 | -73.67 | 19.00 | | 53.39 | 52.08 | 5.28 |
| **P5** | -124.72 | -122.08 | 15.71 | | 60.03 | 60.87 | 5.00 |

Source: the author

In the present study, the mean Polish VOT value for /d/ from the five participants together was -99.56 ms. This VOT value is higher than the one presented by Kopczyński (1977). However, there were two participants (P1 and P4) who produced VOT values close to Kopczyński (1977)'s, while two participants (P2 and P5) produced higher mean VOTs.

The Polish mean VOT for the voiced stop /d/ was in between the productions of the three languages, being lower than the BP VOT mean (-113.13 ms) and higher than the English one (-93.51 ms). In relation to the variability, we see that, similarly to the English and Portuguese VOT values, Polish also showed a huge variability. Figure 17 displays a boxplot of the Portuguese /d/ VOT values of each participant.

Figure 17: Individual variability of the Polish VOT in ms for /d/ per participant
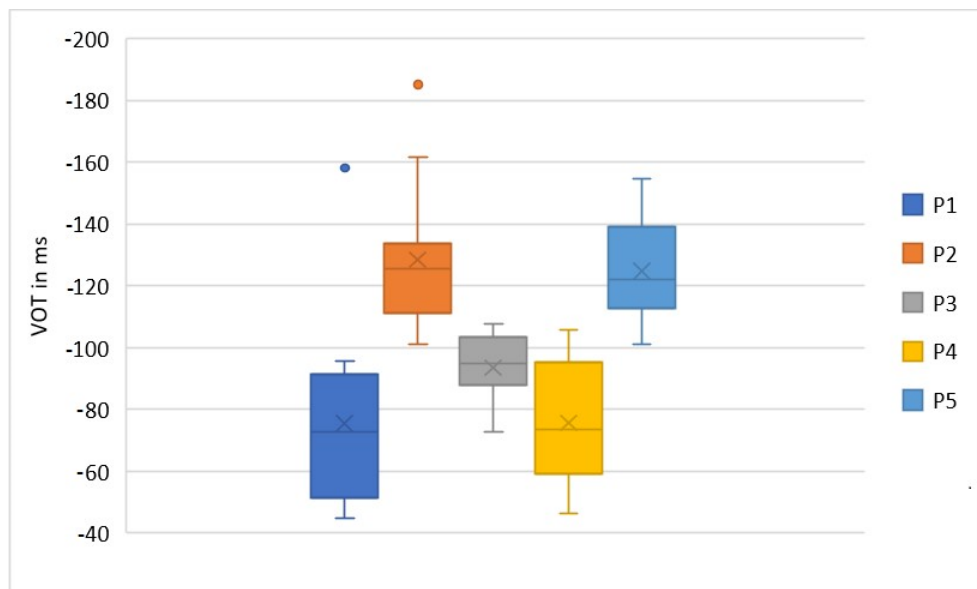


Source: the author

P1's productions for the Polish voiced stop /d/ represented the highest variability of the present study in the three languages. This high variability comes due to the fact that P1 produced an outlier VOT value (-158.15 ms). The other P1's VOT productions were more consistent, varying from -45.03 ms to -95.68 ms. P1 and P4's VOT productions had a very close mean. However, P4 did not produced any outlier value, thus having less variability. P4's VOT productions went from -46,43 ms to -105.84 ms.

P2 was also a participant who produced an outlier value, and this participant's VOT values were the highest for the Polish voiced stop /d/. P2's productions went from -101.07 ms to -161.82 ms, plus the outlier VOT = -185.24 ms.

P3 was the participant with less variability for the Polish voiced stop /d/, having VOT values from -72.64 ms to -107.74 ms. P5's productions had more variability than P3, but did not present a huge variability like P1 and P2. The VOT values from P5 varied from -101.32 ms to -154.59 ms, thus presenting low variability.

Concerning the Polish voiceless stop /t/, the mean of the five participants together was 58.54 ms. It was a higher VOT mean than the BP (56.57 ms) and lower than the English (63.54 ms). The Polish mean in the present study was higher than the one presented in the Review of Literature, /t/ = 33 ms (Kopczyński, 1977). Figure 18 displays the individual variability of the Polish VOT in ms.

Figure 18: Individual variability of the Polish VOT in ms for /t/ per participant
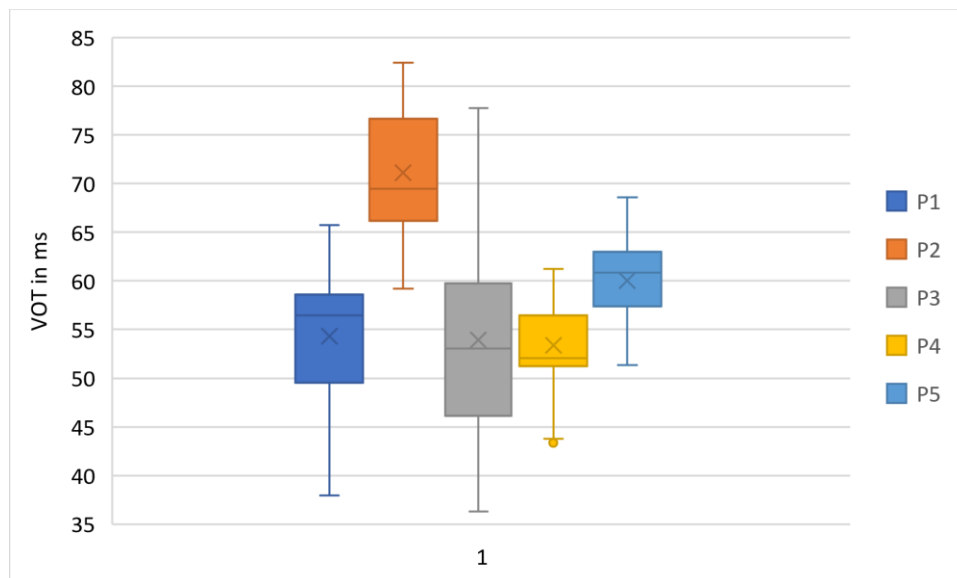


Source: the author

Three of the participants (P1, P3 and P4) had close mean VOTs for the Polish voiceless /t/: P1, /t/ = 54.29 ms; P3, /t/ = 53.90 ms; P4, /t/ =53.39 ms. P3 was the participant with the highest variability, producing VOT from 36.27 ms to 77.74 ms. P1 produced VOT values varying from 37.93 ms to 65.72 ms. P4 had two low productions: 43.78 ms and 43.38 ms, this

last one considered an outlier value, the only for the Polish voiceless stop /t/. The other P4 productions went from 51.03 ms to 61.24 ms.

P2 had the highest VOT mean, having productions from 59.19 ms to 82.42 ms, thus being the participant who produced more aspiration for Polish. P5 had productions varying from 51.34 ms to 68.58 ms, being the participant with the lowest variability for the Polish voiceless stop /t/.

Now, we present the Polish VOT mean of each repetition. As well as in English and BP, each participant produced the words containing the target sounds /t/ and /d/ three times in Polish. Thus, we calculated the mean of the first, second and third repetition for each participant and the mean of the five participants together.

We start by presenting the mean VOT results of the Polish voiced stop /d/. Figure 19 displays the VOT mean of the stop /d/ of each participant by repetition. The dotted lines correspond to the productions of each participant and the solid line represents the mean of the five participants together.

Figure 19: Polish /d/ VOT mean by repetition
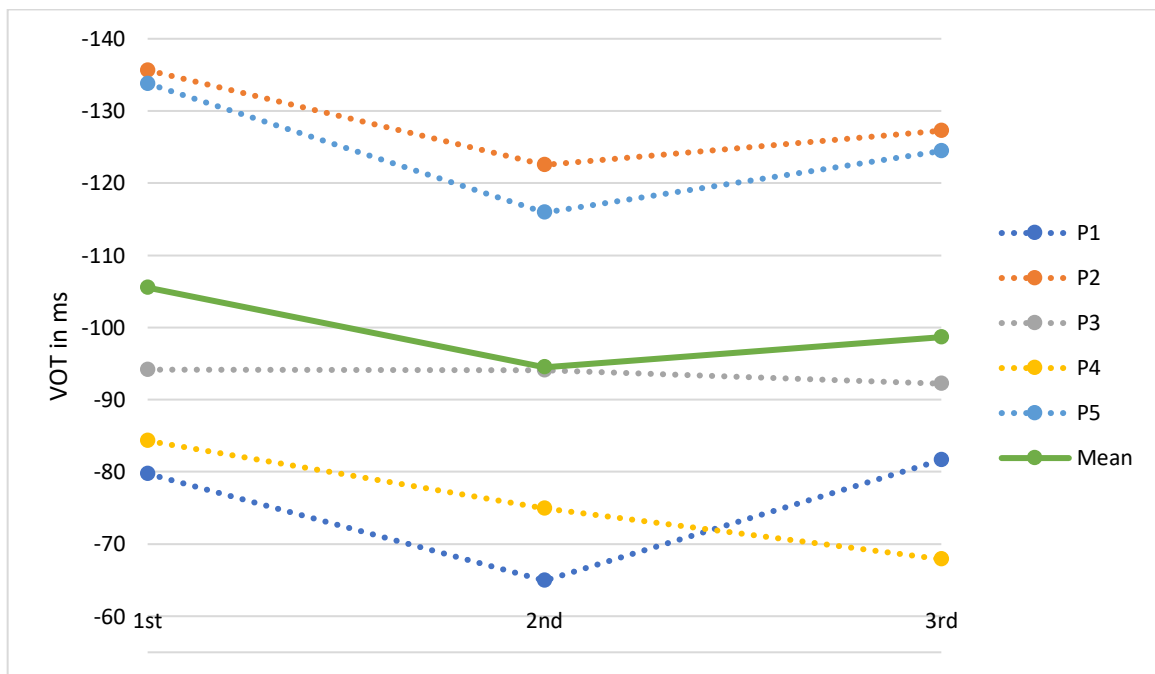


Source: the author

Figure 19 shows that three participants (P1, P2, and P5) had a similar pattern for the productions of the Polish voiced stop /d/. They produced a higher VOT mean for the first repetition, having a decrease in the second repetition and, then, an increase in the third repetition. These three participants produced their lowest VOT mean for the second repetition. P1's highest VOT mean was the last repetition; while P2 and P5 produced their highest VOT mean for the first repetition.

P3 was the participant with less variability, producing a mean VOT for the Polish /d/ of -94.16 ms; then -94.07 ms; and -92.21 ms. Thus, all P3's VOT values together had a SD of 11.28. P3 was the participant who had the VOT values closest to the mean of the five participants together.

For the Polish voiced stop /d/, P4 was the only participant who produced the highest VOT mean in the first repetition, then had a decrease in the second repetition and, again, another decrease in the third one.

Now, we present the VOT values by repetition for the Polish voiceless stop /t/. Figure 20 displays VOT results by repetition in Polish. The dotted lines represent the productions for each participant and, the solid line, the mean of the five participants together.

Figure 20: Polish /t/ VOT mean by repetition
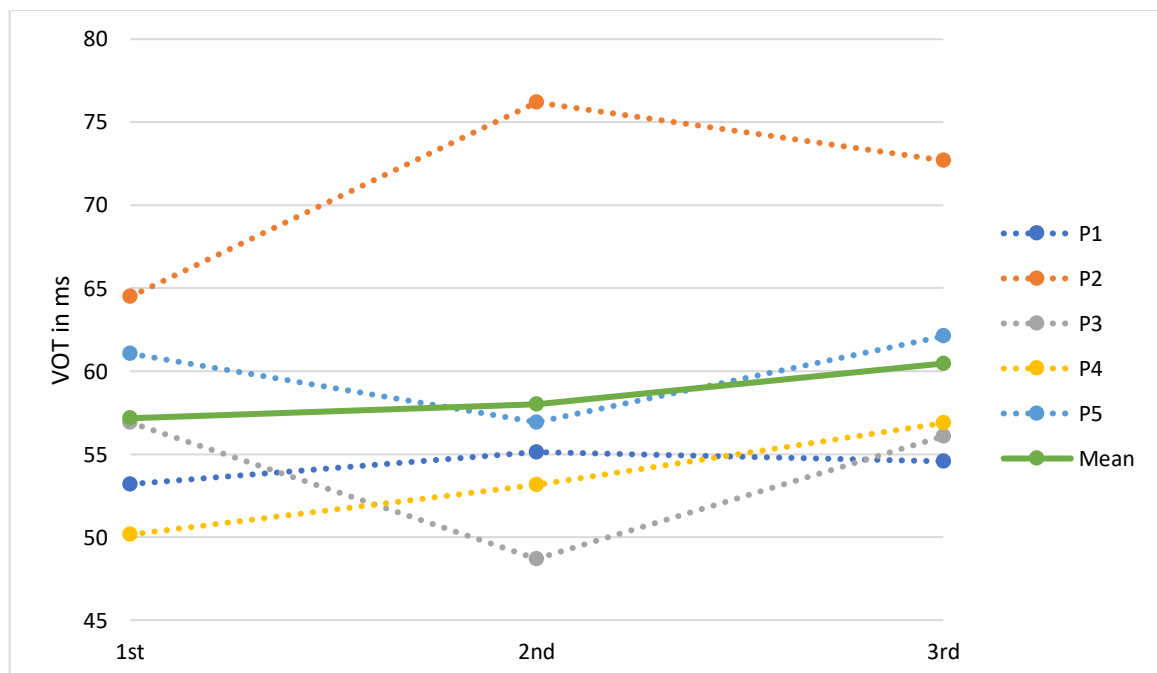


Source: the author

The productions of the Polish voiceless stop /t/ did not present a huge variability. P1 and P2 produced their highest mean VOTs in the second repetition, while their third repetition was closer to the second repetition, but slightly lower. P2 had more variability, while P1 produced very close VOT values.

P3 and P5 produced a VOT mean, in the first repetition, higher than the one in the second repetition. In their third repetition, they had an increase in relation to the second one. P3's highest production was the first repetition, while P5 produced the highest VOT mean in the third repetition. But both, P3 and P5, produced very close mean VOTs in their first and third repetition: P3's first repetition /t/ = 56.91 ms and third repetition /t/ = 56.09 ms; P5's first repetition /t/ = 61.07 ms and third repetition /t/ = 62.10 ms.

P4 maintained a pattern, producing a VOT value of 50.15 ms in the first repetition, increasing to 53.15 ms in the second repetition and, again, increasing to 56.87 ms in the third repetition.

Table 36 displays the number of tokens produced as unaspirated, slightly aspirated, aspirated or highly aspirated stop for Polish. The results of the Polish voiceless stop /t/ indicate that there was a higher level of aspiration in the present study than the VOT values used as reference for monolingual speakers of Polish in the Review of Literature (Kopczyński, 1977). In general, the Polish results in the present study had a close mean to the Portuguese productions, being the overall mean a little higher. Thus, the aspiration produced in Polish was an intermediate value between the three languages. In Polish, there were 48 VOT productions classified as aspirated and 27 classified as slightly aspirated. There was no production classified as unaspirated or highly aspirated.

Table 36: Number of tokens and percentages for Polish /t/ produced as unaspirated, slightly
aspirated, aspirated or highly aspirated by each participant

|  | Unaspirated | | Slightly aspirated | | Aspirated | | Highly aspirated | |
|---|---|---|---|---|---|---|---|---|
|  | N | % | N | % | N | % | N | % |
| **P1** | 0 | 0 | 6 | 40 | 9 | 60 | 0 | 0 |
| **P2** | 0 | 0 | 0 | 0 | 15 | 100 | 0 | 0 |
| **P3** | 0 | 0 | 9 | 60 | 6 | 40 | 0 | 0 |
| **P4** | 0 | 0 | 9 | 60 | 6 | 40 | 0 | 0 |
| **P5** | 0 | 0 | 3 | 20 | 12 | 80 | 0 | 0 |

Source: the author

From P1's productions in the three languages, the Polish VOT was the one that had the highest level of aspiration. While in English P1 produced all the tokens as slightly aspirated; in BP 6.66% of the productions were unaspirated and 93.33% were slightly aspirated; in Polish, 60% of P1's productions were classified as aspirated.

P2 had 33.33% of the productions classified as slightly aspirated and 66.66% as aspirated in BP; in English, 26.66% as aspirated and 73.33% as highly aspirated. In Polish, P2 produced all the tokens as aspirated, being, thus, more aspirated than in BP and less aspirated than in English.

P3 had more aspiration in BP, producing 53.33% of the tokens as aspirated and, as slightly aspirated, 46.66%. In English, P3 had 93.33% of the productions classified as slightly aspirated and, as aspirated, 6.66%. Thus, P3's VOT production in Polish was more aspirated than it was in English and less than in BP.

P4 had the same percentage of slightly aspirated and aspirated in Polish and in English, but the total VOT mean was a little higher in English than in Polish. Portuguese was the language in which P4 produced more aspiration, having 93.33% of the productions classified as aspirated and 6.66% as slightly aspirated.

P5 had all the productions in the three languages classified as slightly aspirated and aspirated. In BP, P5 produced 73.33% of the tokens as aspirated; in Polish, it was 80%; and in English, it was 86.66%.

4.3 VOT DURATION AND MULTILINGUAL SPEAKERS

In this section, we use inferential statistics to compare the VOT values of /t/ and /d/ in the three languages spoken by the participants in the present study. As the sample size is small, non-parametric repeated-measures ANOVAs (Friedman's tests) were used to compare the VOT for /d/ and for /t/.

As Table 37 displays, the Friedman test (see Appendix L) was used to compare the three means and the results show no significant difference for the /t/ VOT values for the three languages ($X^2 = .40$, $p = .81$). Thus, the results indicate that for this group of multilingual speakers, /t/, when produced in isolated words, is an aspirated stop in the three languages. These results differ from previous studies. We can observe that the VOT values for English are slightly higher than for Polish or BP. But we can also see that for English, the standard deviation is higher, thus indicating that the five participants differ considerably in their production of English VOT.

Table 37: Comparison VOT of Friedman Test for /t/

| Language /t/ VOT | Mean | SD |
|:---:|:---:|:---:|
| BP | 56.57 | 6.15 |
| Polish | 58.54 | 7.52 |
| English | 63.54 | 26.55 |

N = 5

Source: the author

Turning to /d/, Table 38 shows the Friedman test (see Appendix M) that was used to compare the three means and the results show no significant difference for the /d/ VOT values for the three languages ($X^2 = 2.80$, $p = .241$). Thus, the results indicate that for this group of multilingual speakers, /d/, when produced in isolated words, has mostly a negative VOT in the three languages, meaning that the release of the closure occurs after the beginning of voicing. These results differ from previous studies (e.g., Prestes, 2013; França, 2011; Wojtkowiak, 2022). We can see that the negative VOT values are higher for BP than for Polish or English,

but these two languages also present higher standard deviations, thus indicating more variance in the VOT values produced by the participants.

Table 38: Comparison VOT of Friedman Test for /d/

| Language /d/ VOT | Mean | SD |
|:---:|:---:|:---:|
| BP | -113.13 | 15.38 |
| Polish | -99.56 | 25.77 |
| English | -93.51 | 24.37 |

N = 5

Source: the author

## 4.4 VOT DURATION IN ENGLISH IN BILINGUAL AND MULTILINGUAL CONTEXTS

In this section, we discuss the English results, using as reference the English VOT references in L2 context, presented in the Review of Literature, section 2.6. As shown in Table 39, for L2 English spoken by L1 speakers of BP, the mean VOT of voiced stop /d/ = -121 ms (Prestes, 2013); and the mean VOT of voiceless stop /t/ = 45.83 ms (França, 2011). For L2 English spoken by L1 speakers of Polish, the mean VOT of voiced stop /d/ = -82.95 ms, and mean VOT of voiceless stop /t/ = 60.93 ms (Wojtkowiak, 2022). In the context of English as an L2, for the voiceless stop /t/, when being Polish the L1, the VOT reference was higher than when the L1 was BP. Whereas for the voiced stop /d/, the L1 BP reference presents a higher value than L1 Polish.

Table 39: Comparison of English mean VOT values produced by bilinguals and multilinguals

| Speakers | English /d/ VOT | /t/ | /d/ |
|:---|:---|:---:|:---:|
| BP/English bilinguals | França (2011) / Prestes (2013) | 45.83 | -121 |
| Polish-English bilinguals | Wojtkowiak (2022) | 60.93 | -82.95 |
| BP/Polish/English multilinguals | Present study | 63.54 | -93.51 |

Source: the author

In the present study, considering the production of the English consonants, the mean VOT of the five participants together was -93.51 ms for the voiced stop /d/ and 63.54 ms for the voiceless stop /t/.

Table 40 displays the mean VOT values for /d/ and /t/ according to L1, L2 and L3 in BP, Polish and English.For the English voiced stop /d/, the mean of the participants in the present study had a closer mean to L1 Polish speakers' reference, being P1 and P3 the participants who produced the closer mean to Wojtkowiak (2022)'s values. However, P1 had Polish as L3, which indicates that there is no influence of Polish in P1's English VOT. P3 learnt Polish before than English, but presented higher VOT in both, BP and Polish than in English.

Table 40: English VOT values according to L1, L2 and L3 in ms

|  | P1 | P2 | P3 | P4 | P5 | Mean |
|---|---|---|---|---|---|---|
| /t/ BP L1 | 45.8 | 60.23 | 57.43 | 60.68 | 58.72 | 56.57 |
| /d/ BP L1 | -124.95 | -127.93 | -109.82 | -89.11 | -113.84 | -113.13 |
| /t/ Polish L2 | - | 71.11 | 53.90 | - | 60.03 | 61.68 |
| /d/ Polish L2 | - | -128.48 | -93.48 | - | -124.72 | -115.56 |
| /t/ Polish L3 | 54.29 | - | - | 53.39 | - | 53.84 |
| /d/ Polish L3 | -75.43 | - | - | -75.71 | - | -75.57 |
| /t/ English L2 | 45.92 | - | - | 54.23 | - | 50.07 |
| /d/ English L2 | -83.53 | - | - | -60.98 | - | -72.25 |
| /t/ English L3 | - | 109.78 | 46.82 | - | 60.97 | 72.52 |
| /d/ English L3 | - | -112.95 | -88.11 | - | -121.99 | -107.68 |

Source: the author

P4 was the participant who produced the lowest VOT mean for the English voiced /d/, not having a mean VOT value close to Wojtkowiak's (2022) or Prestes' (2013) references. P4's L1 was Portuguese, but for the voiced stop /d/, the English VOT results are more similar to the Polish productions.

P2 and P5 had VOT productions closer to Prestes (2013)'s reference. P2 learnt Polish and Portuguese during childhood, while English at age of 15 years old. P2's mean VOT for BP

and Polish were very close, whereas for English it was lower. P5 produced similar mean VOT in English and Polish, and in BP it was lower. P5 had English as L3.

For the voiceless stop /t/, the mean VOT of the five participants from this study was close to Wojtkowiak's (2022) reference, being a little higher. P5's mean VOT was practically the same, being 60.97 ms. P4's mean VOT was lower, but was still closer to Wojtkowiak's (2022) reference, 54.23 ms.

P1 and P3 were the participants who had their mean VOT closer to França's (2011) reference, being P1's mean VOT almost the same, 45.92 ms; whereas P3' was a little higher, 46.82 ms.

P2 presented a high level of aspiration and did not have the mean VOT close to either, França (2011) or Wojtkowiak (2022). Through this analysis, we do not verify any pattern among the participants related to L1, L2 and L3, that is, the participants had different VOT values, independent of English being their L2 or L3.

The pattern that almost all the participants' productions followed was the high variability for the voiced stop /d/. With exception of P3's production for Polish, which had a SD of 11.28, and P4 for English, which had a SD of 10.47, the other productions had a SD varying from 15.39 to 28.88. The voiceless stop /t/ productions had much less variability. The only higher SD was from P2's English productions, which had a high mean VOT (16.3). The other productions had a SD varying from 4.41 to 9.9.

## 5 CONCLUSIONS

In this chapter, we present the final remarks of the present study. Sections 5.1 and 5.2 summarizes the main findings, answering the two research questions of the study. Section 5.3 provides information about the limitations of the study. Section 5.4 describes the pedagogical implications. Finally, in section 5.5, we provide some suggestions for studies that may contribute to the area in the future.

## 5.1 LINGUISTIC PROFILE OF PORTUGUESE, POLISH AND ENGLISH MULTILINGUALS

The results of the present study show that all participants reported using Portuguese most of time, being the mean of the five participants 76% of use per week; Polish, 14.40% per week and English 9.60% per week. Two participants indicated that English was the second language more used, being 25% and 8% of use per week. Two participants reported Polish as the second language used more often, 30% and 20% of use per week. And one participant reported using English and Polish the same amount of time (5% for each) per week.

As for when English and Polish were learnt, three participants reported that, as descendants of Polish immigrants, they had the opportunity to learn Polish in their childhood, either in tandem with Portuguese (P2 and P3) or in early childhood (P5) Conversely, two of them learnt it when they were adults (P1 and P4). Thus, two participants had Polish as heritage language, two had it as their L3, and one had Polish as an L2. All the participants started learning English during their childhood or adolescence, being the earliest 8 years old, and the oldest 15 years old. The present study shows that the Polish as a heritage language is still present in some families, but sometimes the Polish descendants only engage in learning the language in formal contexts, either in childhood or adulthood.

The level of proficiency of the participants was self-reported taking a scale from zero to six. Since all the participants either had BP as their L1 or learnt BP together with Polish during their childhood, all of them had a BP fluency of 6. The English proficiency mean of the five

participants was 5. And for Polish, the mean was 4, mostly because the participants reported having lower level of proficiency in the reading and writing skills, as they learned Polish by interacting or to interact with family and friends.

## 5.2 EFFECTS OF LINGUISTIC EXPERIENCES ON THE PRODUCTION OF THE STOPS

The results indicate that, for the English voiceless stop /t/, the participants produced lower VOT values than the presented in the literature (Lisker; Abramson, 1964). Whereas for BP and Polish the voiceless stop /t/ had higher VOT means than the ones showed by the literature: for BP Klein (1999); and for Polish Kopczyński (1977). The results evidenced that the participants tended to produce more aspiration in English, the language that precisely requires it. Even though the VOT values for BP and Polish were higher than those presented in the literature for monolingual speakers, the participants tended to produced lower VOT values in these two languages. However, the inferential statistics showed no significant differences across the three languages, thus indicating that for this group of multilingual speakers, /t/ is produced with aspiration in the three languages.

For the voiced stop /d/ the results indicated more variation than for the voiceless stop /t/. The highest VOT mean was in BP, followed by Polish and, then, English. The mean VOT values were higher than the reference values showed in the literature in the three languages: for Portuguese, by Klein (1999); for Polish, by Kopczyński (1977); and for English, by Abramson and Lisker (1964). However, the inferential statistics showed no significant differences across the three languages, thus indicating that for this group of multilingual speakers, /d/ is produced mostly with negative VOT values in the three languages.

The VOT results indicated a pattern that may be influenced by the use of the three languages spoken by the multilingual participants. The two participants (P1 and P3) who had reported using Polish more often than English, produced similar VOT values in the three languages. For the voiced stop /d/, the highest VOT mean was in BP, followed by Polish and, lastly, English. For the voiceless stop /t/, both participants produced lower VOT values for English and higher for Polish, whereas for BP, P1 had a lower VOT mean than P3.

The participants who reported using English more often than Polish (P2 and P5) also demonstrated some patterns. For the voiced stop /d/, both produced similar and relatively high VOT values in the three languages. For the voiceless stop /t/ both participants produced more aspiration in English, whereas for BP and Polish they produced lower VOT values. However, P5 had close VOT values in the three languages, whereas P2 had much more aspiration in English than in BP and Polish.

The participant who reported using Polish and English the same amount of time (P4) produced similar VOT values in English and Polish for the voiceless stop /t/, whereas in BP it was higher. For the voiced stop /d/, the highest VOT mean was also in BP, followed by Polish and, then, by English.

Regarding the level of proficiency of the participants, there seems to be no connection between self-reported proficiency and level of aspiration for the voiceless stop /t/. This is evident by the English proficiency reported by P3 and P5, who reported having 6 (scale from 0 to 6) for the four skills, speaking, reading, writing and listening. P3 produced less aspiration in English than in BP and Polish; while P5 produced very close VOT values for the three languages. Moreover, the participant who self-reported the lowest level of proficiency in English and Polish (P4), produced a VOT mean higher than P3 and lower than P5 for the English voiceless stop /t/.

## 5.3 LIMITATIONS OF THE STUDY

A limitation of the present study was the lack of previous studies involving phonetic-phonological development of multilingual speakers, especially for Polish descendants in Brazil. Thus, for purpose of comparison, monolingual and bilingual studies were used as references.

Another limitation of the study was to find Portuguese-Polish-English multilingual speakers with a high level of proficiency in the three languages in the same cities investigated in this study. As a consequence, the study includes data from a small sample, and not robust statistical analysis could be performed. Additionally, the proficiency measure relies on self-reported rates, which means the proficiency level reported by the participants may have been under or overestimated. Furthermore, the VOT data were obtained by asking participants to

record isolated words, but the results could have been different if we had placed the target words in sentences or collected data with less controlled research instruments or even recorded naturalistic speech.

## 5.4 PEDAGOGICAL IMPLICATIONS

Studies involving multilingualism are fundamental for understanding how languages work, how their production differ among speakers of more than one language, and whether these differences, especially in terms of pronunciation, compromise the effectiveness of speech intelligibility. Thus, the present study contributes mainly to the field of BP-Polish-English multilingualism and phonetics, since the objective was to analyze the VOT in in the three languages. Besides that, we believe that this research can also be relevant for those who develop studies involving Polish sociophonetics, seeing that the language history, language use and level of proficiency of the descendants of Polish immigrants were investigated.

The results obtained in the present study showed that the multilingual speakers of BP, Polish and English produced VOT values higher than the presented in the reference literature for monolingual speakers of BP and Polish; and lower than native speakers of English. These results show that investigating multilingual speech patterns are important to help us having a better understanding of crosslinguistic influences.

## 5.5 SUGGESTIONS FOR FURTHER RESEARCH

There are many regions in South of Brazil where multilingual speakers of BP, Polish and English live. This group of people is an open field for further research, either in case of multilingualism, bilingualism or even monolingualism, since there are few studies involving them. For that reason, there are many aspects of phonetics and phonology that were not investigated yet, and can be an important contribution for the area in further research.

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**APPENDIXES**

**APPENDIX A – MEAN VOT, IN (MS) OF THE VOICED AND VOICELESS STOP CONSONANTS IN ENGLISH**

|  | /p/ | /b/ | /t/ | /d/ | /k/ | /g/ |
|---|---|---|---|---|---|---|
| **Lisker and Abramson (1964)** | 58 | 1/-101 | 70 | 5/-102 | 80 | 21/-88 |
| **Baran et al (1977):** |  |  |  |  |  |  |
| **Single word citation form** | 64.3 | -16.4 | 70.6 | -5 | 79.2 | -4.5 |
| **Adult-to-child speech** | 35.7 | -0.3 | 37.6 | 10.3 | 41.4 | 16.2 |
| **Adult-to-adult conversation** | 50.7 | 0.7 | 46.1 | 8.9 | 49.6 | 18 |
| **Oral reading** | 40.4 | 8.8 | 43 | 11.4 | 51.9 | 20.2 |
| **Chodroff (2015)** | 50.8 | 8.7 | 60.5 | 13.8 | 54.4 | 17.2 |
| Source: the author | | | | | | |

**APPENDIX B – MEAN VOT, IN (MS), OF THE VOICED AND VOICELESS STOP CONSONANTS IN BP**

|  | /p/ | /b/ | /t/ | /d/ | /k/ | /g/ |
|---|---|---|---|---|---|---|
| **Klein (1999):** |  |  |  |  |  |  |
| **Sentences** | 15.49 | -104.98 | 17.13 | -93.31 | 33.90 | -76.93 |
| **Isolated words** | 17.70 | -86.57 | 16.78 | -99.20 | 37.82 | -91.16 |
| **Alves et al. (2008):** |  |  |  |  |  |  |
| **Aspirated** | 37.49 | - | 40.67 | - | 47.24 | - |
| **Non-aspirated** | 14.96 | - | 18.28 | - | 17.18 | - |
| **Alves (2015)** | 21 | -93 | 20 | -87 | 55 | -72 |
| **Melo et al. (2017):** |  |  |  |  |  |  |
| **Adults** | - | - | 16.96 | -114.85 | 44.22 | -94.56 |
| **Children** | - | - | 20.47 | -108.78 | 44.05 | -98.47 |
| Source: the author | | | | | | |

**APPENDIX C – MEAN VOT, IN (MS), OF THE VOICED AND VOICELESS STOP CONSONANTS IN POLISH**

| | /p/ | /b/ | /t/ | /d/ | /k/ | /g/ |
|---|---|---|---|---|---|---|
| **Kopcyński (1977)** | 37.5 | -78 | 33 | -72 | 49 | -61 |
| **Keeting et al. (1981)** | 21.5 | -88.2 | 27.9 | -89.9 | 52.7 | -66.1 |
| **Wrembel (2014):** | | | | | | |
| **Study 1** | 23 | - | 33 | - | 60 | - |
| **Study 2** | 22 | - | 34 | - | 57 | - |
| **Sypiańska (2021):** | | | | | | |
| **Bilingual speakers** | 24.3 | -110.6 | 29.5 | -112.3 | 52.3 | -110.3 |
| **Control group** | 21.2 | -129.3 | 25.5 | -119.9 | 46.9 | -115 |
| Source: the author | | | | | | |

**APPENDIX D – PRE-SCREENING QUESTIONNAIRE**

1. Qual é sua primeira, segunda e terceira língua?
2. De 0 a 5, qual nível de proficiência você atribui a sua primeira língua?
3. De 0 a 5, qual nível de proficiência você atribui a sua segunda língua?
4. De 0 a 5, qual nível de proficiência você atribui a sua terceira língua?
5. Onde você reside atualmente?
6. Qual seu local e data de nascimento?

**APPENDIX E – EMAIL INVITATION**

Eu, Deimison Junior Falkievicz, junto com minha orientadora, Drª. Rosane Silveira, da Universidade Federal de Santa Catarina, estamos desenvolvendo uma pesquisa de mestrado com pessoas multilíngues de português, polonês e inglês. A pesquisa é dividida em duas partes: a primeira será responder algumas perguntas para obtermos informações sobre o perfil linguístico de cada participante, o questionário será enviado por e-mail, através do Google Formulários.

Para a segunda parte da pesquisa, será necessária uma reunião online ou pessoalmente, dependendo da disponibilidade de cada participante. Haverá uma apresentação de slides com palavras para português, polonês e inglês, que o participante deverá ler em voz alta enquanto será gravado. A gravação será transformada e analisada em espectrogramas.

Se você concordar em participar da pesquisa, sua ajuda irá contribuir para o campo de estudos linguísticos multilíngues e de estudos com descendentes de imigrantes poloneses. Para participar desse estudo, basta responder esse e-mail.

# Questionário de histórico da linguagem

1.  Nome completo:

    _____

2.  Data de nascimento:

    _____
    *Exemplo: 7 de janeiro de 2019*

3.  Local de nascimento:

    _____

4.  Nível de escolaridade:

    *Marcar apenas uma oval.*

    o   Ensino fundamental completo
    o   Ensino fundamental incompleto
    o   Ensino médio completo
    o   Ensino médio incompleto
    o   Ensino superior
    o   Pós-graduação

5.  Você estudou em escola bilíngue?

    *Marcar apenas uma oval.*

o *Sim*

o *Não*

6. Se sim, quais eram os idiomas?

_____

7. Liste todas as línguas que você sabe em ordem de aquisição (1 sendo sua línguanativa) Ex. 1: Português. 2: Inglês. 3: Espanhol.

_____

_____

_____

_____

_____

8. Indique onde você aprendeu sua língua 2 (marque tantas opções quantas forem necessárias):

*Marque todas que se aplicam.*

☐ *Casa*

☐ *Escola*

☐ *Curso de línguas*

☐ *Sozinho*

☐ *Outro:* _____

9. Indique onde você aprendeu sua língua 3 (marque tantas opções quantas forem necessárias):

*Marque todas que se aplicam.*

☐ *Casa*

☐ *Escola*

☐ *Curso de línguas*

☐ *Sozinho*

☐ *Outro:* _____

10. Informe a idade (em anos) em que você começou a aprender sua língua 2:

_____

11. Informe a idade (em anos) em que você começou a aprender sua língua 3:

_____

12. Informe a idade (em anos) em que você começou a utilizar ativamente sua língua 2:

_____

13. Informe a idade (em anos) em que você começou a utilizar ativamente sua língua 3:

_____

14. Informe a idade (em anos) em que você se tornou fluente em sua língua 2:

_____

15. Informe a idade (em anos) em que você se tornou fluente em sua língua 3:

_____

**Indique, em uma escala de 0 a 6 (0 = nada, 6 = muito), o quanto cada um dos fatores a seguir contribuiu para a aprendizagem de sua língua 2:**

16. Interação com a família:

*Marcar apenas uma oval.*

|  | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
|  | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

17. Interação com os amigos:

*Marcar apenas uma oval.*

|  | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
|  | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

18. Leitura:

*Marcar apenas uma oval.*

|  | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
|  | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

19. Televisão:

*Marcar apenas uma oval.*

|  | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
|  | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

20. Filmes:

*Marcar apenas uma oval.*

|   | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
|   | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

21. Rádio/música:

*Marcar apenas uma oval.*

|   | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
|   | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

22. Internet:

*Marcar apenas uma oval.*

|   | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
|   | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

23. Cursos de língua:

*Marcar apenas uma oval.*

|   | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
|   | ○ | ○ | ○ | ○ | ○ | ○ | ○ |

24. Outro:

_____

25. Outro:

*Marcar apenas uma oval.*

| | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

**Indique, em uma escala de 0 a 6 (0 = nada, 6 = muito), o quanto cada um dos fatores a seguir contribuiu para a aprendizagem de sua língua 3:**

26. Interação com a família:

*Marcar apenas uma oval.*

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

27. Interação com os amigos:

*Marcar apenas uma oval.*

| | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
| | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ | ☐ |

28. Leitura:

*Marcar apenas uma oval.*

|   | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
|   | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

29. Televisão:

*Marcar apenas uma oval.*

|   | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
|   | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

30. Filmes:

*Marcar apenas uma oval.*

|   | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
|   | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

31. Rádio/música:

*Marcar apenas uma oval.*

|   | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
|   | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

32. Internet:

*Marcar apenas uma oval.*

|   | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
|   | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |

33. Cursos de língua:

*Marcar apenas uma oval.*

|   | 0 | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|---|
|   | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |

34. Outro:

_____

35. Outro:

*Marcar apenas uma oval.*

|   | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
|   | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |

_____

36. **Marque a língua em que você:**

*Marque todas que se aplicam.*

|   | Língua 1 | Língua 2 | Língua 3 |
|---|---|---|---|
| Fala com seu pai | ☐ | ☐ | ☐ |

| | | | |
|---|---|---|---|
| Fala com sua mãe | ☐ | ☐ | |
| Fala com familiares | ☐ | ☐ | ☐ outros |
| Fala com amigos | ☐ | ☐ | ☐ |
| Fala no trabalho/escola | ☐ | ☐ | ☐ |
| Lê/escreve no trabalho/escola | ☐ | ☐ | ☐ |

**37. Marque a frequência com que você:**

*Marcar apenas uma oval por linha:*

| | Sempre | Frequentemente | Às vezes | Raramente | Quase nunca | Nunca |
|---|---|---|---|---|---|---|
| Fala com seu pai | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Fala com sua mãe | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Fala com outros familiares | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Fala com amigos | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Fala no | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

trabalho/escola

Lê/escreve no
trabalho/escola

1      **Estime a porcentagem do tempo em que você usa cada língua semanalmente (o total deve ser de 100%):**

38.  Língua 1:

_____

39.  Língua 2:

_____

40.  Língua 3:

_____

**Estime em número de horas o quanto você usa cada língua para as seguintes atividades semanalmente:**
          Língua 1:

41.  Ver tv/filmes

_____

42.  Ouvir música

_____

43. Ler

_____

44. Escrever

_____

45. Falar

_____

**Estime em número de horas o quanto você usa cada língua para as seguintes atividades semanalmente:**

Língua 2:

46. Ver tv/filmes

_____

47. Ouvir música

_____

48. Ler

_____

49. Escrever

_____

50. Falar

_____

**Estime em número de horas o quanto você usa cada língua para as seguintes atividades semanalmente:**

Língua 3:

51. Ver tv/filmes

_____

52. Ouvir música

_____

53. Ler

_____

54. Escrever

_____

55. Falar

_____

**56. Marque em que língua você:**

_Marque todas que se aplicam._

|  | Língua 1 | Língua 2 | Língua 3 |
|---|:---:|:---:|:---:|
| Conta: | ☐ | ☐ | ☐ |
| Faz cálculos: | ☐ | ☐ | ☐ |
| Faz anotações: | ☐ | ☐ | ☐ |
| Expressa raiva: | ☐ | ☐ | ☐ |
| Expressa afeição: | ☐ | ☐ | ☐ |

**Marque, em uma escala de 1 a 6, seu nível de proficiência nas línguas que sabe:**

(1= muito baixo; 2 = baixo; 3 = razoável; 4 = bom; 5 = muito bom; 6 = proficiente)

### 57. Língua 1
*Marcar apenas uma oval por linha.*

|  | 1 | 2 | 3 | 4 | 5 | 6 |
|---|:---:|:---:|:---:|:---:|:---:|:---:|
| Leitura | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |
| Escrita | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |
| Compreensão Auditiva | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |
| Fala | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ | ⬭ |

### 58. Língua 2
*Marcar apenas uma oval por linha.*

|  | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Leitura | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Escrita | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Compreensão Auditiva | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Fala | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

**59. Língua 3**
  *Marcar apenas uma oval por linha.*

|  | 1 | 2 | 3 | 4 | 5 | 6 |
|---|---|---|---|---|---|---|
| Leitura | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Escrita | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Compreensão Auditiva | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |
| Fala | ◯ | ◯ | ◯ | ◯ | ◯ | ◯ |

60. Marque a língua em que você se sente mais confiante ao:

  *Marcar apenas uma oval por linha.*

| Língua 1 | Língua 2 | Língua 3 |
|---|---|---|
| ◯ | ◯ | ◯ |

| Ler | | | |
| --- | --- | --- | --- |
| Escrever | ⬭ | ⬭ | ⬭ |
| Compreender | ⬭ | ⬭ | ⬭ |
| Falar | ⬭ | ⬭ | ⬭ |

61. Caso você já tenha realizado algum teste de proficiência, indique: língua, teste,ano, pontuação.

62. Caso haja outra informação que você ache importante sobre o aprendizado ou uso de suas línguas, por favor, escreva abaixo:

Google Formulários

For this study, we have made a few changes in Scholl and Finger's (2013) questionnaire.

The adaptions were the following: questions regarding use of language were modified into weekly, instead of daily use. Two questions about school bilingualism were also included, because we were interested in knowing if the participants had school influence in their language knowledge. Besides that, the following L1 questions were removed, because for our study they were not dimed relevant:

1. Indicate where you learn your L1.

2. Inform (in years) the age you started learning your L1.

3. Inform (in years) the age you started using your L1 actively.

4. Inform (in years) the age you became fluent in your L1.

5. Indicate in a scale from 0 to 6 (0= nothing, 6= a lot) how much each of the following factors have contributed for your L1 learning: a. Interaction with your family; b. Interaction with your friends; c. Reading; d. Television; e. Movies; f. Radio/Music; g. Internet; h. Language course; i. Other.

6. Inform how many months you have spent in each of the following environments: a. Country the language is spoken; b. Family the language is spoken; c. School/ work the language is spoken.

## APPENDIX G – WORDS FOR PRODUCTION TESTS

Words containing /d/ and /t/:

|  | **/d/** | **/t/** |
|---|---|---|
| **PORTUGUESE** | DADO | TAPA |
|  | DELA | TETO |
|  | DAVA | TAÇA |
|  | DEDO | TESE |
|  | DOCE | TOPA |
| **POLISH** | DAWA (give) | TATA (dad) |
|  | DOBRY (good) | TOWAR |
|  | DESER (dessert) | (commodity) |
|  | DATA (date) | TERAZ (ago) |
|  | DESKA (board) | TAKI (such) |
|  |  | TEKSTY (text) |
| **ENGLISH** | DAD | TAP |
|  | DOLL | TOP |
|  | DOOR | TALL |
|  | DOG | TALK |
|  | DESK | TEST |

Distractors:

| **PORTUGUESE** | CASA | NOVE |
|---|---|---|
|  | LÁPIS | RIO |
|  | CAMA | BAIXO |
|  | PIANO | MATA |
|  | RUA | LAMA |
|  | SOL | NEVE |
|  | BOCA | MAÇA |
|  | HOJE | ALGA |
|  | FACA | MEL |

|  | PAPEL | FLOR |
|---|---|---|
| **POLISH** | PIES (dog) | KOT (cat) |
|  | FLAGA (flag) | LEWO (left) |
|  | LAT (year) | PARA (pair) |
|  | LIS (fox) | GUMA (rubber) |
|  | WODA (water) | SMAK (flavor) |
|  | NOGA (leg) | UFNY (confident) |
|  | MATKA (mother) | WINO (wine) |
|  | ILE (how much) | ZERO (zero) |
|  | KOLOR (color) | GAZETA (newspaper) |
|  | BLISKO (near) | NOS (nose) |
| **ENGLISH** | NAME | PAPER |
|  | BLUE | WEEK |
|  | FIVE | SONG |
|  | SCHOOL | CAR |
|  | PLANE | RED |
|  | BOOK | OVER |
|  | MUSIC | MONEY |
|  | THIS | THINK |
|  | THERE | THUNDER |
|  | THOUGH | THOUGHT |

# APPENDIX H – PRODUCTION TESTS

## PORTUGUESE

| | | | | |
|---|---|---|---|---|
| Testes de produção oral<br><br>1 | Português<br>Sua primeira tarefa será ler as palavras que serão apresentadas nos slides a seguir em voz alta. Cada slide irá conter uma palavra em português e será substituído para o próximo automaticamente a cada quatro segundos.<br>2 | Português<br>Tome cuidado e tente fazer o máximo de silêncio possível, pois qualquer barulho, como ruídos ou cliques no computador, poderá prejudicar a qualidade do áudio de sua gravação.<br>3 | Leia em voz alta, uma única vez, cada palavra que aparecer a partir do próximo slide. Pronto? Vamos começar!<br>4 | TETO<br><br>5   00:04 |
| DADO<br>6   00:04 | FLOR<br>7   00:04 | DELA<br>8   00:04 | FACA<br>9   00:04 | TESE<br>10   00:04 |
| TAPA<br>11   00:04 | MEL<br>12   00:04 | DAVA<br>13   00:04 | PAPEL<br>14   00:04 | DADO<br>15   00:04 |
| TAPA<br>16   00:04 | ALGA<br>17   00:04 | DAVA<br>18   00:04 | TAÇA<br>19   00:04 | DEDO<br>20   00:04 |
| TESE<br>21   00:04 | DADO<br>22   00:04 | RUA<br>23   00:04 | DAVA<br>24   00:04 | SOL<br>25   00:04 |
| TETO<br>26   00:04 | CAMA<br>27   00:04 | DELA<br>28   00:04 | TOPA<br>29   00:04 | CASA<br>30   00:04 |
| DOCE<br>31   00:04 | LÁPIS<br>32   00:04 | TOPA<br>33   00:04 | NOVE<br>34   00:04 | PIANO<br>35   00:04 |
| TAPA<br>36   00:04 | DOCE<br>37   00:04 | RIO<br>38   00:04 | DELA<br>39   00:04 | BOCA<br>40   00:04 |
| TAÇA<br>41   00:04 | HOJE<br>42   00:04 | BAIXO<br>43   00:04 | TOPA<br>44   00:04 | MATA<br>45   00:04 |

| | | | | |
|---|---|---|---|---|
| TESE | LAMA | DOCE | NEVE | TAÇA |
| 46   00:04 | 47   00:04 | 48   00:04 | 49   00:04 | 50   00:04 |
| DEDO | MAÇA | TETO | DEDO | |
| 51   00:04 | 52   00:04 | 53   00:04 | 54   00:04 | 55 |

## POLISH

| | | | | |
|---|---|---|---|---|
| ◄)   Po polsku<br><br>Teraz, czas na polskie słowa. Twoje zadanie jest takie samo. Będziesz musiał przeczytać każde słowo, które pojawia się w prezentacji. Słowa będą się zmieniać co cztery sekundy. | DAWA | WINO | DOBRY | DESER |
| 56   ✶ | 57   00:04 | 58   00:04 | 59   00:04 | 60   00:04 |
| TATA | KOLOR | TEKST | LAT | DATA |
| 61   00:04 | 62   00:04 | 63   00:04 | 64   00:04 | 65   00:04 |
| BLISKO | DESKA | TATA | DOBRY | TOWAR |
| 66   00:04 | 67   00:04 | 68   00:04 | 69   00:04 | 70   00:04 |

| | | | | |
|---|---|---|---|---|
| TERAZ | DAWA | DESKA | TAKI | DOBRY |
| 71   00:04 | 72   00:04 | 73   00:04 | 74   00:04 | 75   00:04 |
| LEWO | ZERO | DESER | MATKA | TEKST |
| 76   00:04 | 77   00:04 | 78   00:04 | 79   00:04 | 80   00:04 |
| PIES | FLAGA | DAWA | LIS | TERAZ |
| 81   00:04 | 82   00:04 | 83   00:04 | 84   00:04 | 85   00:04 |

| | | | | |
|---|---|---|---|---|
| TAKI | WODA | DESKA | NOGA | TERAZ |
| 86   00:04 | 87   00:04 | 88   00:04 | 89   00:04 | 90   00:04 |
| TOWAR | ILE | KOT | DATA | TAKI |
| 91   00:04 | 92   00:04 | 93   00:04 | 94   00:04 | 95   00:04 |
| PARA | TATA | GUMA | TEKST | SMAK |
| 96   00:04 | 97   00:04 | 98   00:04 | 99   00:04 | 100   00:04 |
| GAZETA | NOS | TOWAR | UFNY | DATA |
| 101   00:04 | 102   00:04 | 103   00:04 | 104   00:04 | 105   00:04 |

## ENGLISH

| | | | | |
|---|---|---|---|---|
| English<br><br>Your last task is in English. The procedure is the same as it was in Portuguese and in Polish. You will have to read each word that appear in the slide presentation every four seconds. | DESK | MONEY | TALK | THIS |
| 106   * | 107   00:04 | 108   00:04 | 109   00:04 | 110   00:04 |
| DAD | THERE | DOG | TALL | RED |
| 111   00:04 | 112   00:04 | 113   00:04 | 114   00:04 | 115   00:04 |
| DOG | WEEK | DESK | TAP | SONG |
| 116   00:04 | 117   00:04 | 118   00:04 | 119   00:04 | 120   00:04 |

| | | | | |
|---|---|---|---|---|
| TALL | NAME | DOLL | TALK | BOOK |
| 121　00:04 | 122　00:04 | 123　00:04 | 124　00:04 | 125　00:04 |
| TAP | PLANE | TOP | TALK | BLUE |
| 126　00:04 | 127　00:04 | 128　00:04 | 129　00:04 | 130　00:04 |
| THINK | DAD | TOP | SCHOOL | DOOR |
| 131　00:04 | 132　00:04 | 133　00:04 | 134　00:04 | 135　00:04 |

| | | | | |
|---|---|---|---|---|
| MUSIC | DESK | TAP | TEST | FIVE |
| 136　00:04 | 137　00:04 | 138　00:04 | 139　00:04 | 140　00:04 |
| DOOR | TEST | TALL | PAPER | DAD |
| 141　00:04 | 142　00:04 | 143　00:04 | 144　00:04 | 145　00:04 |
| THOUGH | CAR | DOOR | OVER | TEST |
| 146　00:04 | 147　00:04 | 148　00:04 | 149　00:04 | 150　00:04 |

| | | | | |
|---|---|---|---|---|
| DOLL | THUNDER | TOP | DOG | THOUGHT |
| 151　00:04 | 152　00:04 | 153　00:04 | 154　00:04 | 155　00:04 |
| DOLL | | | | |
| 156　00:04 | | | | |

**APPENDIX I – CONSENT FORM**

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

A PRODUÇÃO ORAL DE FALANTES MULTILÍNGUES PORTUGUÊS-POLONÊS-INGLÊS

Nós, Rosane Silveira (pesquisadora responsável e professora do Programa de Pós-Graduação em Inglês) e Deimison Junior Falkievicz (aluno da Pós-Graduação – mestrado) da Universidade Federal de Santa Catarina, estamos convidando você, falante de português brasileiro, polonês e inglês, a participar de um estudo intitulado "a produção oral de falantes multilíngues português-polonês-inglês". A pesquisa atende a todas as especificações da Resolução 466/2012. Como a pesquisa envolve etapas virtuais, seus procedimentos obedecem às orientações dispostas no Ofício Circular No 2/2021/CONEP/SECNS/MS.

A pesquisa tem como objetivo fazer uma análise do perfil linguístico de falantes multilíngues de português, polonês e inglês. Além disso, pretendemos analisar características da fala produzida em cada um dos três idiomas.

Se você concordar em participar da pesquisa, haverá duas tarefas para realizar: a primeira consiste em responder um questionário sobre seu perfil linguístico, desenvolvido em português. As perguntas serão sobre a aquisição dos idiomas, uso de cada idioma, atitudes linguísticas e proficiência. O questionário será enviado por e-mail e você irá respondê-lo de forma online, pelo Google Formulários. O tempo estimado para a realização dessa atividade é de quinze minutos. Para a segunda atividade, será necessária uma reunião online, através do Google Meet. Haverá uma apresentação de slides que você terá que ler em voz alta, enquanto o áudio será gravado. Você lerá um parágrafo em português e, em seguida, trinta palavras no mesmo idioma. Depois, você lerá um parágrafo em polonês, em seguida, mais trinta palavras no mesmo idioma. Por último, você lerá um parágrafo em inglês e trinta palavras no idioma. O tempo estimado para a realização dessa atividade é de aproximadamente vinte minutos.

Existem alguns riscos relacionados ao estudo, que precisam ser mencionados. Dentre eles, desconforto, constrangimento e cansaço. Além disso, por utilizar o ambiente virtual, alguns imprevistos de ordem tecnológica podem ocorrer, como instabilidade e qualidade da

conexão com a internet. Para a minimização desses riscos e desconfortos, desenvolvemos atividades que não demandem muito tempo para a sua realização.

Os benefícios diretos esperados com essa pesquisa são compreender algumas características da fala nos idiomas português brasileiro, polonês e inglês por falantes multilíngues. Os benefícios indiretos estão ligados à compreensão de como descendentes de imigrantes poloneses aprendem e utilizam a língua polonesa, além das línguas portuguesa e inglesa. Esperamos, ainda, contribuir com as discussões sobre ensino e aprendizagem de línguas estrangeiras, de herança e multilinguismo.

Para esclarecer eventuais dúvidas que você possa ter e fornecer as informações que queira antes, durante ou depois de encerrado o estudo, os pesquisadores Rosane Silveira e Deimison Junior Falkievicz, responsáveis por este estudo, poderão ser localizados através do endereço de e-mail rosanesilveira@hotmail.com e/ou falkievicz22@gmail.com, e através do telefone (47) 9 9783-1021; bem como pelos telefones (48) 3721-9455, (48) 3721-9819, ou e-mail ppgi_@contato.ufsc.br, Programa de Pós-Graduação em Inglês - PPGI, Universidade Federal de Santa Catarina, Centro de Comunicação e Expressão – CCE "B"– Sala 313 Campus Universitário – Trindade – Florianópolis – SC 88.040-900.

A sua participação na pesquisa é voluntária e, caso não queira mais fazer parte desse estudo, poderá desistir a qualquer momento.

As informações relacionadas ao estudo poderão ser conhecidas por pessoas autorizadas, que são, exclusivamente, os pesquisadores desse estudo, cujos nomes já foram citados nesse termo. No entanto, qualquer informação que for divulgada em publicação ou relatório, será feita de modo codificado, para que sua identidade seja totalmente preservada e mantida sua confidencialidade.

Todo o material obtido será utilizado unicamente para nossa pesquisa de mestrado, sendo componente de nossa metodologia e análise dos dados, mantendo o sigilo da identidade dos nossos participantes.

Não haverá despesas para a realização da pesquisa e você não receberá nenhum valor em dinheiro pela sua participação. Ainda que a pesquisa não preveja gastos com aquisição de equipamento, deslocamento ou alimentação, o participante tem direito a ressarcimento e indenização caso haja algum dano material ou imaterial ocasionado pela pesquisa, e esse seja

devidamente comprovado. Este documento garante o reparo ao dano que deve ser pago de acordo com a Resolução 510/16.

Quando os resultados forem publicados, seu nome não aparecerá, mas sim um código. Os pesquisadores declaram ainda conhecer e cumprir os requisitos da Lei Geral de Proteção de Dados (Lei No 13.709, de 14 de agosto de 2018 quanto ao tratamento de dados pessoais e dados pessoais sensíveis que serão utilizados para a execução da presente pesquisa.

Caso o(a) participante não queira continuar a participação na pesquisa ou que os dados coletados não sejam usados, não há nenhum problema. A desistência pode ocorrer a qualquer momento, sem qualquer prejuízo para o participante ou para a pesquisa. Basta entrar em contado com os pesquisadores através dos números de telefone ou e-mail informados nesse documento.

Se você tiver dúvidas em relação a seus direitos como participante de pesquisa, você também pode entrar em contato com o Comitê de Ética em Pesquisa com Seres Humanos (CEPSH/UFSC) da Universidade Federal de Santa Catarina, pelo e-mail cep.propesq@contato.ufsc.br e/ou pelo telefone (48) 3721-6094. R. Desembargador Vitor Lima, n° 222, 7° andar, sala 701 Trindade 88040-400 – Florianópolis – SC. O comitê de ética em pesquisa é um órgão colegiado multi e transdisciplinar, independente, que existe nas instituições que realizam pesquisa envolvendo seres humanos no Brasil e foi criado com o objetivo de proteger os participantes de pesquisa em sua integridade e dignidade, bem como assegurar que as pesquisas sejam desenvolvidas.

.....................................................

Você deverá fazer sua rubrica em todas as páginas desse termo e assinar em duas vias, sendo uma delas para o participante da pesquisa.

Concordo em participar da pesquisa.

_____

Participante

Florianópolis-SC, \_\_\_\_\_ de _____ de 2023

**APPENDIX J – REQUIREMENT FOR USE OF A UNESPAR'S ROOM**



Universidade Federal de Santa Catarina

Centro de Comunicação e Expressão

Programa de Pós-Graduação em Inglês: Estudos Linguísticos e Literários

# Requerimento: <u>Carta dirigida à coordenação do curso de letras português/inglês – UNESPAR -UV</u>

Nome do/a Aluno/a: <u>Deimison Junior Falkievicz</u>

Fone: <u>(47) 997831021</u>

E-mail: <u>falkievicz22@gmail.com</u>

Orientadora: <u>Rosane Silveira</u>

Ano/Semestre de Ingresso: <u>2022/1</u>

Nível: ME ( X ) DO (    )

Possui Bolsa: SIM ( X ) NÃO (  )

# A PRODUÇÃO DE OCLUSIVAS ALVEOLARES POR FALANTES MULTILÍNGUES DE PORTUGUÊS-POLONÊS-INGLÊS

*Justificativa:*

O objetivo principal da pesquisa em questão é de analisar algumas propriedades fonéticas dos fonemas /t/ e /d/, no idiomas português, inglês e polonês. Será feito uma análise fonética acústica desses fonemas, com descendentes de imigrantes poloneses do norte de Santa Catarina e sul do Paraná, falantes multilíngues de português, polonês e inglês. Como principal aporte teórico são utilizadas a teoria variocinista (Labov, 1972) e a sociofonética, (Di paolo; Yaeger-Dror, 2011). A pesquisa também aborda questões sociolinguísticas, com intuito de poder identificar características de pronúncia que estejam relacionadas à experiência linguísticas dos participantes. Há a hipótese de que a língua polonesa tenha tanta influência na aprendizagem da língua inglesa quanto a portuguesa. Para coletar os dados há dois instrumentos: um questionário online, desenvolvido no Google formulários; e uma

apresentação de slides, com palavras que têm os fonemas alvos desse estudo. Para obter esses dados será feita reuniões presenciais e individuais de aproximadamente quinze minutos para cada participante, para que se obtenha uma melhor qualidade de áudio, já que haverá uso de microfone. Será necessário um espaço físico adequado para essa etapa. A Universidade Estadual do Paraná, em União da Vitória, é um lugar de fácil acesso para todos os participantes da pesquisa, cerca de cinco pessoas. Por essa razão, pedimos encarecidamente o apoio do Colegiado de Letras Português/inglês e da Unespar, para a realização dessa parte da pesquisa. Garantimos dar a devida descrição e reconhecimento da assistência prestada pela Unespar e pelo Colegiado de letras português/ inglês na dissertação final do trabalho. Posteriormente, para a análise dos dados, será utilizado análise de oitiva e análise acústica com o programa Praat, que tem a função de analisar sons através de ondas em parâmetros como intensidade, frequência e comprimento.

 

_____          Florianópolis, 24/04/2023

Assinatura digital do Aluno

# APPENDIX K – UNESPAR'S PROTOCOL

**UNIVERSIDADE DO ESTADO DO PARANÁ**
*Campus* **de União da Vitória**

**PARANÁ**
GOVERNO DO ESTADO

## COLEGIADO DE LETRAS PORTUGUÊS/INGLÊS

### ATA DE REUNIÃO DO COLEGIADO DE LETRAS PORTUGUÊS E INGLÊS Nº 006/2023

Aos vinte e cinco dias do mês de abril de dois mil e vinte e três, reuniram-se, às dez horas, em sessão extraordinária, os docentes colegiados abaixo nominados para discutir a cessão/empréstimo da sala "de laboratório de línguas" (sala onde se realizava o Programa Paraná Fala Inglês e, que, no momento, está sem computadores e funcionando como sala de orientações de TCC do curso; sala de aula quando pesquisas se fazem necessárias, em função de internet; sala de atendimentos a alunos; etc.) do Curso de Letras Português e Inglês para realização de pesquisa pelo egresso Deimison Junior Falkievicz. A pesquisa versa sobre "A produção de oclusivas alveolares por falantes multilíngues de Português-Polonês-Inglês" e está sendo desenvolvida na Universidade Federal de Santa Catarina - UFSC, sob a orientação da Doutora Rosane Silveira. A solicitação do egresso se fez acompanhar de carta-requerimento de sua orientadora. Os docentes colegiados concordaram com a cessão/empréstimo da sala e incentivaram o egresso em sua pesquisa. A Direção Geral do Campus foi comunicada quando do contato inicial do pesquisador. Sem mais, findou-se a reunião colegiada e lavrou-se esta ata.

Bernardete Ryba

Valéria de Fátima Carvalho Vaz Boni

Ivete Pauluk

Michele Schneiders

Giselle Ludka

Aleksandra Cibelly Finkler

**UNIVERSIDADE DO ESTADO DO PARANÁ**
*Campus* de União da Vitória

Mônica Cristina Metz

Ana Paula Gomes do Nascimento

Josoel Kovalski.

**APPENDIX L – FRIEDMAN TEST FOR /t/**

| Friedman Test | | | | |
|---|---|---|---|---|
| Factor | Chi-squared | Df | p | Kendall's W |
| **Language /t/ VOT** | 0.400 | 2 | 0.819 | 0.040 |
| Source: the author | | | | |

**APPENDIX M – FRIEDMAN TEST FOR /d/**

| Friedman Test | | | | |
|---|---|---|---|---|
| **Factor** | **Chi-squared** | **Df** | **p** | **Kendall's W** |
| Language /d/ VOT | 2.800 | 2 | 0.247 | 0.280 |
| Source: the author | | | | |