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Cross-Linguistic Influence of L2 on L1 in Speech of Late Bilinguals

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Abstract

The master's thesis focuses on the topic of crosslinguistic interference, investigating speech production of L1 Czech L2 English bilingual students of translation and interpreting. Its main aim was to discover whether these experienced late bilinguals, who live in an L1 dominant environment and acquired their L2 predominantly through instruction, experience L2 to L1 phonetic interference. The investigated features were Czech and English voiceless stops /p, t, k/ and Czech vowels /u, uː, o, oː, a, aː/ with similar English counterparts /ʊ, u, ɒ, ɔ, ʌ, ɑ/. The results showed that bilinguals as a group did not differ from a functional monolingual control group, however, individual data suggest that occurrence of L2 to L1 interference may take place at least for some of such late bilinguals. The theoretical part of the thesis summarizes research on the topic of bi-directional interference, the practical part describes present research aims, methodology, information about participants, data analysis, results and reflection on the results.

Key words

bilingual speakers, monolingual speakers, cross-linguistic interference, speech production, voiceless stops, central and back vowels, VOT, formants, interpreting

Abstrakt

Tato diplomová práce se zabývá mezijazykovou interferencí, konkrétně zkoumá produkci řeči bilingvních studentů překladu a tlumočení, jejichž rodným jazykem je čeština a druhým osvojeným jazykem je angličtina. Hlavním cílem práce bylo zjistit, zda se v rodné řeči těchto pozdně bilingvní mluvčích, kteří si osvojili anglický jazyk v rámci školní výuky a žijí v českém prostředí, projeví interference z druhého osvojeného jazyka. Interference byla zkoumána na českých a anglických explozivách /p, t, k/ a českých samohláskách /u, uː, o, oː, a, aː/ s podobným protějškem v angličtině /ʊ, u, ɒ, ɔ, ʌ, ɑ/. Analýza výsledků ukázala, že se produkce bilingvních mluvčích jako skupiny nelišila od funkčně monolingvní kontrolní skupiny. Individuální výsledky však naznačují, že se interference z druhého osvojeného jazyka v rodném jazyce může objevit v řeči alespoň některých těchto pozdně bilingvních mluvčích. Teoretická část práce shrnuje výzkum týkající se mezijazykové interference, praktická část popisuje cíle této práce, metodologii, informace o účastnících, analýzu dat, výsledky a diskuzi nad výsledky.

Klíčová slova

bilingvní mluvčí, monolingvní mluvčí, mezijazyková interference, produkce řeči, neznělé explozivy, střední a zadní samohlásky, doba nástupu hlasivkového tónu, formanty, tlumočení

Content

1 Introduction

As Pavlenko (2000) describes, a traditional focus of studies on second language phonology was the influence of the first acquired language on the pronunciation of the second acquired language. This exploration of uni-directional L1 to L2 interference might be attributed to the fact that research was rooted in the maturational constrains theory. However, the situation has changed in the view of findings that language competence remains somewhat adaptable in the course of life. Nowadays, cross-linguistic interference is studied as a bidirectional phenomenon (e. g. Flege 1987; Harada 2003, MacLeod, Stoel-Gammon and Wassink 2009; Kang and Guion 2006; Bergmann et al. 2016).

The relative importance of factors governing the manifestation of L2 to L1 interference seems to remain unclear together with the pattern of interference, even though as Yang and Fox (2017) state, L2 to L1 interference might be more likely to manifest itself in case of early learners due to the non-stability of their L1 language system. Nevertheless, studies on the language attrition show that even late learners' L1 can be subjected to L2 influence (e.g. Bergmann et al. 2016, Major 1992).

This study aims to contribute to the studies on L2 to L1 interference by investigating speech production of experienced late bilingual learners in L1 dominant environment who acquired their L2 through learning and instruction. The study assumes that even though the bilinguals are instruction learners in an L1 dominant environment, the L2 interference will occur since they are experienced L2 speakers and L2 experience showed itself to be a factor determining occurrence and degree of interference in a number of studies (Yang and Fox 2017, Baker and Trofimovich 2005, Major 1992).

The L1-L2 interaction will be observed on Czech voiceless stops /p, t, k/ and their English counterparts as well as on Czech back and central vowels /u, u:, o, o:, a, a:/ and English back vowels that are assumed to be perceived as similar /ʊ, u, ɒ, ɔ, ʌ, ɑ/. The study is interested in finding whether the bilinguals created new L2 categories distinct from their L1 phonemes, and if so, how this incorporation of L2 categories into their phonological system affected their L1. The category creation will be investigated by comparing bilinguals' production in their L1 and L2, possible L1 changes will be examined by comparing bilinguals' production to a production of a functional monolingual control group. Although Flege' s (1995) Speech Learning Model claims that the probability of establishing new separate phonetic categories for similar phones L2 phones decreases with the onset of L2 learning, and by that account, late learners are more likely to share a single category for both L1 and L2 similar phones, which leads to the approximation of characteristics of L2 and L1 phones, the model also stresses that the processes employed in L1 learning can mediate L2 learning at any point in life. Further, if bilinguals establish separate categories for L1 and L2 phones, changes in L1 categories may occur, e. g. motivated by maintaining phonological contrast between the categories. Therefore, if L2 to L1 interference occurs, the study also aims to observe its pattern – whether the characteristics of investigated L1 phones will move to resemble L2 phones or rather, they move away from the L2 phones (as discussed by Yang and Fox 2017).

The final question investigated in the study is whether a degree of activation of languages influences the interference. Namely, if there is a difference in language production when both bilingual’s languages are active, that is production in a bilingual mode, as opposed to language production when only the language produced is active, a monolingual mode (Grosjean and Li (2013, 14–18). That will be investigated by comparing L1 (L2) production in interpreting task and in a mere L1 (L2) repetition task.

2 Literature review

2.1. Cross-linguistic Interference

As Odlin (2003) states, to describe interaction between languages, various terms are used such as language transfer, linguistic interference, cross-linguistic influence or language mixing. The list includes also some additional expressions that specify more closely the direction of the interaction, namely native language influence or the role of the native language which imply uni-directional effects of L1 on L2.

Although the term language mixing frequently occurs in the foreign language acquisition literature, its meaning seems to be more specific in comparison to the meaning of other introduced terms. Pfaff (1979) views language-mixing as a term that encompasses borrowing, calquing and code-switching phenomena. Bokamba (1989, 278) speaks about code mixing and defines it as "…embedding of various linguistic units such as affixes (bound morphemes), words (unbound morphemes), phrases and clauses from two distinct grammatical (sub-) systems within the same sentence and speech event".

As Odlin (2003) further adds that most commonly and interchangeably used terms are language transfer and cross-linguistic influence. Although as Odlin (2003) indicates, many consider these terms to be synonymous, Pavlenko (2000) further distinguishes among them. She views language transfer as "…processes that lead to the incorporation of elements of one language into another (e.g., borrowing or restructuring)…" (Pavlenko 2000, 176). On the other hand, cross-linguistic influence is according to her a more general term, encompassing both transfer and "…any other kind of effect one language may have on the other (e.g., convergence or attrition)" (Pavlenko 2000, 176).

In the field of phonetics and phonology, the most frequently used terms appear to be cross-linguistic influence and cross-linguistic interference (see Antoniou et al. 2011, Simonet 2014, Antoniou et al. 2010, Yang and Fox 2017, Fowler et al. 2008, Wrembel 2014, Hopp and Schmid 2013, etc.). Their interchangeability is reflected in Simonet's definition of language interference: "[the] influence of a bilingual's two languages either uni- or bi-directional..." (Simonet 2014, 26). Pavlenko (2000) further specifies that this influence is involuntary and applies both to bilingual's competence and performance.

In the light of the discussion above, this paper on phonetic cross-language interaction will therefore adopt Simonet's (2014) definition of language interference and will use terms cross-linguistic interference and influence synonymously.

2.2. Research in Second Language Acquisition

As Ulbrich and Ordin (2014) summarize, the research in foreign language acquisition traditionally investigated the effect of a first language (L1) on the acquisition of the second language (L2), often with regard to the appropriate age of L2 learning (see e.g. Asher and García 1969; Oyama 1976; Flege, Frieda, and Nozawa 1997). Ulbrich and Ordin (2014) continue to explain that the study of the cross-linguistic influence in the opposite direction has been rather neglected and the early bi-directional research focused mostly on children who acquired their L1 and L2 simultaneously. However, this situation has changed, and the contemporary research investigates sequential bilinguals as well, both early and late. Further, the occurrence of L2 to L1 interference has been explored in various areas of linguistic competence such as pragmatics, morphosyntax, lexis, rhetoric, but the most extensive research data exist for the phonological level (Pavlenko 2000, Ulbrich and Ordin 2014). The obtained data offer abundant evidence that not only that the L1 has an effect on the L2, but the L2 influences learners' L1 as well (e. g. Major 1992; Harada 2003; Fowler et al. 2008; de Leeuw, Mennen, and Scobbie 2012; Bergmann et al. 2016, etc.). Finally, the first evidence that the phonetic cross-linguistic interference is bidirectional even for late learners appeared in 1970s (Ulbrich and Ordin 2014), nevertheless, the first formal study dealing with late learners was most likely conducted by Flege in 1987, (Hopp and Schmid 2013).

The contemporary studies on phonetic cross-linguistic interference are concerned with a number of research aims. Their first aim tends to be the confirmation (or disconfirmation) of the existence of bidirectional interference, or rather its manifestation (or the lack of it) in speech of a specific group of bilinguals, and the implications (e. g. Ulbrich and Ordin 2014, Bergmann et al. 2016 – see the section Research findings for an overview). As indicated above, a great number of studies reported L2 to L1 interference, however, there were also some that fail to find any bidirectional interaction (e. g. MacLeod, Stoel-Gammon, and Wassink 2009). This raises questions such as whether the L2 to L1 interference is manifested in speech of all bilinguals or whether the L2 experience and further factors play a role in the matter. In other words, it could be argued that another aim of the studies is observation of factors that might play role in the interference manifestation such as age of acquisition, L2 experience, phone similarity (e. g. Yang and Fox [2017] studied the effect of L2 experience on L1, Baker and Trofimovich [2005] compared influence of participants' age of acquisition). Finally, the studies are interested in the pattern of the interference, such as whether the L1 sound in question will adapt its characteristics to resemble L2 sound or whether it will move away from the L2 sound. In addition, the global goal common to the studies is to determine how the languages are organized in bilingual's brain and to provide support to existing theoretical models (or to disconfirm these models).

2.3. Aspects studied

To observe the interference, the studies focus on various aspects such as: VOT (e. g. Harada 2003, Stoehr et al. 2017) vowel formant frequencies (Yang and Fox 2017, Baker and Trofimovich 2005), formant frequencies of the lateral approximant /l/ (de Leeuw, Mennen, and Scobbie 2012), rhoticity (Ulbrich and Ordin 2014), intonation (Mennen 2004), word-final obstruent voicing (Dmitrieva, Jongman, and Sereno 2010). Nevertheless, most frequently, the interference seems to be explored on the production of VOT (Ulbrich and Ordin 2014). The aspects investigated in the thesis, that is VOT and vowel formant frequencies, will be discussed in more detail in the following paragraphs.

2.3.1. VOT

Voice onset time, abbreviated to VOT, is "[the] interval between the release of a closure and the start of the voicing…" (Ladefoged and Johnson 2011, 151). The first to investigate production of stops in different languages using the criterion of voice onset time were Lisker and Abramson (1964) in their study on voicing of initial stops (Chao and Chen 2008). As Stoehr et al. (2017) note, the VOT is a crucial acoustic tool that enables to differentiate voiced stops from voiceless stops. That is because, as Lisker and Abramson (1964) explain, the division of voiced and voiceless stops based on the presence or absence of voicing during the period of closure is not entirely satisfactory. The authors clarify that although the absence of voicing during the closure signals voiceless stops in many languages, in other, for example in English, the matter is more complex. In English, the production of voiced stops is characterized by the vibration of vocal cords during closure in the medial position. However, in the initial position, there is frequently no presence of voicing and to successfully distinguish English voiced and voiceless stops, criterions of aspiration and articulatory force are employed as well. Therefore, the authors suggested using VOT as a tool for comparison of stops in different languages, reasoning that voice onset time is connected to all three of the stated criterions, and at the same time easily measured.

2.3.1.1. Classification on the basis of VOT

Stoehr et al. (2017) classify the stops according to their VOT values, defining thus pre-voiced, short lag, and aspirated stops – with negative, short positive, and long positive VOT respectively. The authors further explain that VOT based phonetic categories can correspond to different phonological categories in different languages. For example, as reported in Harada (2003), in Japanese, short lag stops correspond to the phonological category of voiceless stops. The phonological category of voiced stops is then realized as pre-voiced stops. On the other hand, in English, short lag stops correspond to the phonological category of voiced stops, as opposed to voiceless stops that are aspirated.

The discussed classification of stops is present in Cho and Ladefoged (1999) as well, in nearly identical terms: voiced, voiceless unaspirated and voiceless aspirated stops. According to the authors, it is likely that all languages have phonological contrast among the maximum of three VOT categories. They explain that although some languages have a phonological contrast among e. g. four different types of stops, there are still merely three VOT distinctions in these languages, and the final phonological contrast is signaled by further properties other than VOT. Nonetheless, as regards the phonetic description, they believe that three categories are not satisfactory for comparison among different languages since stops in each language can occupy different parts of the VOT continuum.

The classification of stops according to their VOT was discussed already in Lisker and Abramson (1964). In their research, authors classify stops in investigated languages based on their distinguishing function in a language. They explored stops in languages that contrast two, three and four stop categories. Theoretically, four phonological categories of stops, such as e. g. voiced aspirated, voiced unaspirated, voiceless aspirated and voiceless unaspirated stops in Hindi, should result in four different VOT categories in a given language. However, based on their results for four category languages, VOT did not differ for all four of the categories, in accordance with the observations made by Cho and Ladefoged (1999), as discussed above. Lisker and Abramson (1964, 403) further concluded that the stop categories in all languages might always occur in specific parts of the VOT continuum, namely either from -125 to -75, from 0 to 25, or from 60 to 100 ms.

In conclusion, the authors seem to agree both on the existence of the maximum of three possible VOT categories with distinctive function within a language, and the fact that the exact VOT intervals for contrasting categories differ across languages. As indicated above, the maximum of three contrasting VOT categories denotes limitations connected to the use of VOT for comparison stops across languages, which will be discussed below.

2.3.1.1.1. Limitations of VOT

Although VOT has proved to be a useful tool, it cannot successfully distinguish stops in all languages (Lisker and Abramson (1964). Its limitations are discussed in Abramson and Whalen (2017). The authors present examples of languages in which the VOT criterion is not sufficient to differentiate among the stop categories, provide explanations thereof, and offer possible alternative criterions.

As an example, Abramson and Whalen (2017) introduce Hindi. As previously mentioned, Hindi is a language with four phonological categories of stops: voiced and voiceless stops occur both aspirated and unaspirated. Voiced aspirated and voiced unaspirated stops overlap on the VOT continuum and the criterion for distinguishing these two categories is a phonation type. Unlike voiced unaspirated stops, aspirated stops are accompanied by a murmur in the closure phase of the production, however, it is pointed out that the murmur does not need to occur in all cases.

Yet, as Abramson and Whalen (2017) illustrate, not only four-category languages pose a problem for VOT based description. Korean is an example of a language with three phonological stop categories, having unaspirated, slightly aspirated and heavily aspirated stops. The problem regarding Korean stops is the differentiation between unaspirated and slightly aspirated stops. When preceded by voicing non-initially, slightly aspirated stops are voiced. Further, when the stops are in the initial position, they are all unaspirated. Although Korean stops can be described in terms of VOT and the description may be satisfactory in some specific contexts, it is said that further parameters may help with the identification of stop categories in Korean. For example, Kang and Guion (2006) in their study on English and Korean stops, in addition to VOT, measured also differences in harmonics H1-H2 at the beginning of the stop-following vowel and the fundamental frequency (F0) at the midpoint of the vowel.

Although it might be necessary to include measurements of additional parameters in case of specific languages, such as those discussed above, additional parameters might complicate the straightforward cross-language comparisons enabled by VOT (Abramson and Whalen 2017).

2.3.1.1.2. Variation in VOT

2.3.1.1.2.1. Linguistic factors

2.3.1.1.2.1.1 Place of articulation

As it is frequently noted, the place of articulation has an effect on the VOT (Cho and Ladefoged 1999, Chao and Chen 2008, Stoehr et al. 2017, Lisker and Abramson 1967). Individual componential factors that together form a single collective factor of place of articulation are summarized by Cho and Ladefoged (1999). Among these main componential factors belong namely: degree of backness of the constriction, rate of the movement of articulators and the size of the contact area. The VOT increases together with the degree of backness of the constriction and the size of the contact area. In contrast, the faster the articulator rate, the lower the VOT.

Cho and Ladefoged (1999) further provide a list of possible explanations for the reported phenomena. The explanation for increase of VOT due to degree of backness of constriction seems to rest on the application of aerodynamical principles. The place of articulation determines the size of the cavity behind and in front of the constriction. According to the principles, to achieve voicing, the pressure in the oral cavity must differ from the pressure in the area behind the constriction. If the cavity behind the constriction is smaller, as in the case of velar stops, there will be a smaller amount of air in the cavity behind the constriction, and the compression of the smaller amount of air should lead to a higher pressure (as opposed to the pressure for more fronted place of constriction). Therefore, the higher the pressure, the longer the time necessary for decreasing the pressure to the level suitable for the vocal cord vibration. A different reasoning is that if the constriction is located in the back of the oral cavity, there is a larger space filled with air in front of the constriction. This air needs to be pushed out first when the air compressed behind the constriction is released. Thus, the larger the space in front of the constriction, the longer time needed for the decrease in pressure behind the constriction, leading to a higher VOT.

Cho and Ladefoged (1999) further explain the influence of the rate of the movement of articulators on VOT. The premise is following: the faster the movement of an articulator, the faster the release of the air, and thus shorter the time before the establishment of the appropriate pressure for the onset of voicing. Building on the premise, the VOT should be the lowest for (apico) alveolars, as the tip of the tongue is reportedly the fastest articulator due to its small size and light weight, followed by the lower lip and the tongue body, which is the largest in mass. This, however, is not fully consistent with the overall reports on VOT, which place the bilabial stops in the position of the lowest VOT among the English stops.

Cho and Ladefoged (1999) therefore proceed to list further factors affecting VOT values, such as the articulatory contact. It was observed that the wider the contact area of the articulators, the higher is the VOT. A possible explanation of this observation dwells in differences in the increase of volume velocity, a phenomenon that is said to determine the decrease rate of pressure in the oral cavity. If the extent area (the constriction area) is wide, as in case of the velar stops, the increase in the volume velocity is relatively slow, and thus the decrease of the pressure is gradual. On the other hand, the opposite applies for bilabial stops which are characterized by the rapid decrease of pressure in the oral cavity. Finally, the alveolar stops are placed somewhere in between velar and bilabial stops in terms of the increase and decrease rates.

As regards the voiceless aspirated stops, another factor noted by Cho and Ladefoged (1999) may impact VOT values, namely the degree of opening of the glottis. After the release of the closure, the open glottis is narrowed so that the vibration of the vocal cords can take place. The rate of the narrowing of the glottis might be slower for velar stops due to the slow decrease of the intraoral pressure, as argued above. Consequently, the VOT of velar stops should be higher (as opposed to bilabial and alveolar stops). Finally, it was proposed that there is a fixed period for which the vocal cords are open, this time period being divided between the closure and aspiration. The longer the closure, the shorter the VOT, and accordingly the shorter the closure, the longer the VOT.

The above presented componential factors explain why the place of articulation has a significant effect on VOT. However, even though the place of articulation is probably the most thoroughly explored complex factor, there are further factors, both linguistic – such as speech rate or phonetic context – and non-linguistic, e. g. age and gender (Yao 2009). Therefore, further VOT variables will be briefly discussed in the following paragraphs.

2.3.1.1.2.1.2 Speech rate (word duration)

As Yao (2009) says, the VOT is reported to vary with the speech rate, more precisely, with the increasing speech rate, the VOT values decrease. However, as Stölten, Abrahamsson, and Hyltenstam (2015) elaborate, the research indicates that both the VOT and vowel duration change equally in response to different speech rates and thus their duration ratio remains largely unaltered. In other words, rather than influencing merely the VOT, speech rate affects the duration of words, and consequently the VOT as well. Therefore, as the authors recommend, syllable or word duration should be considered when measuring the VOT.

2.3.1.1.2.1.3 Phonetic context

Yao (2009) further mentions the influence of phonetic context, illustrating that it has been observed e. g. that in comparison to stops followed by vowels, stops followed by sonorant consonants had a longer VOT, and that the height of the vowel has shown to the influence the VOT values as well.

This was investigated e.g. by Nearey and Rochet (1994) in their study on French and English stops. The researchers discovered that high vowel context caused the VOT rise in case of alveolar and velar stops both in French and English. For French labial stops, the VOT did not manifest the same tendency, leading authors to the conclusion, when taking further research on this topic into consideration, that the vowel interactions with labial stops may be more varied. The study also revealed language differences, as French showed much greater VOT caused by the vowel context than English.

In another study, Mortensen and Tøndering (2013) explored the effects of the vowel context on production of Danish stops. Unlike the above discussed Nearey and Rochet's study (1994), where the participants produced syllables in a frame sentence, Mortensen and Tøndering's (2013) study analyzed the vowel impact on syllable initial stops in spontaneous speech. The results showed that while VOT changed with vowel height in case of Danish voiced unaspirated stops, with stop–high vowel sequence characterized by longer VOT, Danish aspirated voiceless stops were not affected by the context of the following vowel. The authors provide a possible explanation of the phenomena related to the assumed explanation of the influence of the following vowel height.

Mortensen and Tøndering's (2013) explanation is following: for the onset of vocal cord vibration, there must be a difference in the air pressure below and above the glottis, with the lower value above. In the production of stops, the pressure above the glottis increases as a result of the constriction. After its release, it decreases again since the air withheld due to constriction escapes. The rate of the escape is influenced by the width of the passageway, the wider the passage, the faster the pressure decreases to a required level. Since high vowels are characterized by a narrow space in the oral cavity, they slow down the escape rate and increase the VOT. The authors argue that the VOT of Dutch voiceless stops may be long enough to get the required level of pressure before the start of the voicing so that the height of the vowel may not have an impact on the pressure decrease. However, if we consider the results acquired by Nearey and Rochet (1994) who investigated English stops and measured considerably high VOT values of voiceless stops and yet observed vowel context effect, the explanation may be somewhat different.

Although the above presented studies do not share entirely identical results, they indicate that the vowel context may influence the VOT. In addition to the discussed linguistic factors, Kaur (2015) also includes stress, noting that stressed voiceless stops will have longer VOT as compared to the unstressed.

2.3.1.1.2.2. Non-linguistic factors

Yao (2009) discusses a number of non-linguistic factors, such as age and gender as well. It has been observed in several studies that women had higher VOT values than men. Further research has brought some inconclusive results regarding the impact of age on VOT – some researchers reported shorter VOT for older speakers, other found no effect.

2.3.1.1.3. VOT of Czech and English stops

As Roach (2004) states, the English consonant system includes six oral stops: voiceless bilabial /p/ and voiced /b/, voiceless alveolar /t/ and voiced /d/, and velar voiceless /k/ and voiced /g/. As he continues to explain, voicing in voiced stops is rather weak and initial voiceless stops followed by vowels show aspiration. Nakai and Scobbie (2016, 1) provide indicative data on VOT, illustrating that English voiced stops are short-lag and place on the continuum around 15 ms and lower and voiceless stops are long-lag and place on the continuum around 30 ms and higher. Average VOT values of English voiceless stops are reported already in Lisker and Abramson (1964, 394) and can be seen in Table 1 on the following page.

The Czech inventory of stops is somewhat richer including palatal voiced /ɟ/ and voiceless /c/ as well – in addition to the above discussed English inventory (Volín and Skarnitzl 2018, 102–103). Contrary to English, Czech voiced stops are pre-voiced and voiceless stops classify as unaspirated (short-lag) (Podlipský and Šimáčková 2015). Rounded illustrative values of a Czech speaker were borrowed from Podlipský, Šimáčková, and Chládková (2013, 549) and are presented in Table 1 below.

English	**VOT (in ms)**	**Czech**	**VOT (in ms)**
/p/	58	/p/	7
/t/	70	/t/	14
/k/	80	/k/	23

Table 1: VOT of voiceless stops in English and Czech

The table shows illustrative VOT values of English and Czech voiceless labial, alveolar and velar stops (in ms). The English values are borrowed from Lisker and Abramson (1964, 394), values for a Czech speaker are taken from Podlipský, Šimáčková, and Chládková (2013, 549).

2.3.1.2. Formant Frequencies

As Ladefoged and Johnson (2011, 19–21) explain, vowels are traditionally classified on the basis of the setting of articulators, namely according to the horizontal and vertical position of the tongue and the presence or absence of lip rounding. However, as the authors subsequently note, the characterization of vowels according to the articulatory setting is not perfectly precise. In other words, the vowel phonemes belonging to a certain category are not defined by the fully identical articulatory properties: e. g. high vowels /i/ and /u/ do not share the exact same high position of the tongue. Neither does this classification reflect the shape of the tongue or the size of pharynx, which can differ significantly.

As Ladefoged and Johnson (2011, 87–89) elaborate, it is not easy to determine the exact position of the tongue and the movement of the tongue when producing vowels, thus it may be more suitable to speak about the auditory quality of vowels. Although there is a relationship between the auditory qualities of vowels and the tongue position in production of vowels, the correspondence is only approximate. Instead, to determine auditory qualities of vowels, acoustic phonetics is used.

Namely, as Skarnitzl and Volín (2012) claim, the most frequently used method for description of vowels is measuring their formants. As Ladefoged and Johnson explain (2011, 307), formants are "…resonating [frequencies] of the air in the vocal tract". They further add that, for the description of vowels, it is sufficient to know three lowest formants: F1, F2 and F3 (Ladefoged and Johnson 2011, 187). Other authors such as Palková (1994, 172) or Skarnitzl and Volín (2012) specify that it is the first two, not necessarily the first three formants, which are needed for satisfactory description.

As Skarnitzl and Volín (2012) note, the advantages of formant measuring include representing vocalic systems using two parameters with shared unit of measurement and constructing a model of vocalic system that to a limited extent corresponds to articulation. Therefore, it is a frequently used method for comparison of vowel production among speakers (e. g. Baker and Trofimovich 2005; MacLeod, Stoel-Gammon and Wassink 2009, Chang 2011) and it will be employed in the present study as well. At the same time, it is not possible to characterize vocalic systems of all languages by these two parameters, since some languages make use of different types of phonation (e. g. creaky voice) and the phonation type in these languages has a distinctive function (Skarnitzl and Volín 2012).

2.3.1.2.1. English and Czech back vowels

As Jakšič and Šturm (2017) point out, English does not represent a single accent but subsumes a number of varieties. Thus, the non-native learners of English may draw on more than one variety as a point of reference for their production. Although it is desirable for the learners to become familiar with as many varieties as possible in order to improve accent perception abilities, within the education system, the teachers usually opt for one of two main varieties, either the American (GA) or British variety (RP). The chosen variety is then considered as the pronunciation target for the learners. According to the authors' informal assessment, it is the British variety, more specifically Received Pronunciation, that is preferred in the Czech schools. Further, their assessment is supported by studies on teaching trends in Europe. Thus, the present study will primarily refer to RP pronunciation and will include vowel phoneme /ɒ/ that is absent in GA (Cruttenden 2014, 87).

The vocalic system of RP has eleven monophthongs: /i: ɪ, u:, ʊ, ɛ, æ, ɔ:, ɒ, ʌ, ɑ:, ɜ:/ (Hawkins and Midgley (2005). As Cruttenden (2014, 100) states, English vowels differ among each other not only in their length (quantity) but in articulatory setting (quality) as well. He explains that although there are long and short vowel oppositions such as /u/ and /u/ in words pull and pool, it is the quality of the vowels that functions as the decisive factor in distinguishing among vowels. The only exception may be long mid central vowel /ɜ/ which is according to Crutteden (2014, 100) said to share quality with short mid central vowel /ə/, the short vowel appearing typically merely in unstressed syllables.

The vowels investigated in the present study are, as described by IPA (International Phonetic Association 2018): back close rounded vowel /u/ , near back near close /ʊ/, back open-mid rounded /ɔ/, back open rounded vowel /ɒ/, back open unrounded /ɑ/ and back open-mid unrounded vowel /ʌ/. It is necessary to point out that although according to

International Phonetic Association (2018), the /ʌ/ symbol is identified as back, open mid unrounded vowel, Cruttenden (2014, 122) notes that this short vowel is more centralized than the symbol used, adding that the usage of this symbol is due to convention and a frequent usage of its back variant in dialects. For illustration, formant values of investigated vowels, borrowed from Bjelaković (2017, 32), can be seen in Table 2 below.

Average formant values of selected English vowels (men)		
Vowel	**F1 (Hz)**	**F2 (Hz)**
/ʌ/	610.1	1260.9
/ɑ/	625.4	1119.7
/ɒ/	544.9	956.7
/ɔ/	405.4	747.4
/ʊ/	389.6	1344.6
/u/	316.9	1683.7

Table 2: Formant frequencies of selected English vowels

The table shows average formant frequencies in Hertz of English speakers (men) calculated based on data reported by Bjelaković (2017, 32).

As regards the Czech vowel system, as Palková (1994, 170-171) claims, the system is relatively simple, and the standard Czech language uses five long and five short vowels. Volín and Skarnitzl (2018, 102) describe vowels as follows: front close long vowel /i:/, front near close short /ɪ/, front mid long /e:/, front mid short /e/, central open long /a:/, central open short /a/, back mid long /o:/, back mid short /o/, back close long /u:/, and back close short /u/. The five long vowels and their short counterparts are traditionally said to share the auditory quality, with the exception of high close vowels /ɪ/ and /i/ (Skarznitzl and Volín 2012). The long /i/ is characterized as more closed and less centered as opposed to the short /ɪ/ (Volín and Skarnitzl 2018, 16). As (Skarznitzl and Volín 2012) point out, the significance of this difference is reflected even in the usage of two different symbols for each phoneme, whereas for the rest of the short and long pairs, the symbol is identical, with a colon marking the vowel length. So, unlike in English, where all vowels differ both in quality and quantity (Cruttenden 2014, 100), the Czech system seems to be more uniform, with differences dwelling in the vowel length. However, Skarnitzl and Volín (2012) report on qualitative changes taking place, namely that back close /u/ and /u:/ phonemes are starting to differ in more than the duration of the vowel, although this trend is yet not reflected in the usage of symbols. The Czech vowels investigated in this study are back vowels /o, o:, u, u:/ and central vowels /a, a:/. For illustration, in the Table 3 you can see formant frequencies of the investigated Czech vowels borrowed from Skarnitzl and Volín (2012, 9)

Average formant values of selected Czech vowels (men)		
Vowel	**F1 (Hz)**	**F2 (Hz)**
/a/	648.5	1286.0
/a:/	698.6	1206.3
/o/	457.7	1054.8
/o:/	483.7	1027.9
/u/	359.2	936.6
/u:/	304.1	768.9

Table 3:Formant frequencies of selected Czech vowels

The table shows average formant frequencies (in Hertz) of Czech male speakers borrowed from Skarnitzl and Volín (2012, 9).

2.4. Theoretical background for the research

As Pavlenko (2000) and Flege (1995) explain, the theoretical basis for second language acquisition research was initially the maturational constraints theory. According to this theory, after individual reaches a critical period that signifies neurological maturation of the brain, his or her language competence will cease to adapt to new sounds. Therefore, the individual cannot learn L2 perfectly and thus second language acquisition research focused merely on L1 to L2 unidirectional interference. As Pavlenko (2000) further discusses, the contemporary research on phonology shows that language competence continues to adapt to a certain degree throughout the life. Therefore, learning a new language might cause restructuring of the L1, even to the point of sounding as a non-native speaker of the L1. Finally, the model that accounts for these changes and is nowadays used as a reference point for many studies which are discussing bidirectional interference is Flege's (1995) Speech Learning Model (see e.g. Harada 2003, MacLeod, Stoel-Gammon and Wassink 2009, Kang and Guion 2006, Yang and Fox 2017, Bergmann et al. 2016, etc.).

2.4.1. Speech Learning Model

Flege's (1995) Speech Learning Model (SLM) provides a possible explanation of the inability of many late bilinguals to produce L2 sounds authentically, as well as explains why the L1 pronunciation of bilinguals might be affected as well. The model presumes a shared phonological space for L1 and L2. During the acquisition of L1 in childhood, contrastive phonetic categories for L1 are established. However, these categories continue to adapt in time in order to account for properties of all encountered phones (both L1 and L2) which are judged to be a realization of a particular category. When learning L2 there are two possible outcomes. Either a new phonetic category for an L2 sound is formed or learners identify a particular L2 sound as an instance of an L1 category. As age of acquisition increases, the probability of creating a new separate category for non-contrastive sounds in L2 are decreasing. This is what Flege (1995) calls mechanism of equivalence classification. Equivalence classification (Flege 1987, Flege 1995) refers to a phenomenon when learners classify phones that are similar in the L2 as a part of a corresponding category of L1 phones. In other words, one phonetic category is used for perceptually similar L1 and L2 sounds, resulting in the merge of characteristics of the L1 and L2 similar phones. Bilingual's production of L2 phones will thus not be native-like, and at the same time, their production of the L1 may be affected as well. However, even if a bilingual establishes a new phonetic category for L2 sounds, this category might differ from monolingual's category due to a shared phonological space. The bilingual's category might either be adapted to maintain contrast between L1 and L2 categories or his/her representation could be constructed on different features.

Some of the assumptions of this model are shared by other models, such as by the Perceptual Assimilation Model (Best and Tyler 2007), or by Second Language Linguistic Perception Model (van Leussen and Escudero 2015), namely that the learners keep adapting to new sounds they are exposed to.

2.4.2. Perceptual Assimilation Model

Best and Tyler's (2007) Perceptual Assimilation Model (PAM) focuses on how learning a new language influences learner's speech perception and aims to account for his or her perceptual difficulties. As indicated above, the model assumes constant adaptation of learner's competence in response to new sounds, and a shared phonological space for learner's languages.

According to Best and Tyler (2007), when L1 speakers hear an L2 phone, they will "assimilate" it to the L1 phone most resembling L2 phone in articulation. Three situations might arise. Firstly, learners might perceive the L2 phone as an instance of L1 phoneme and the phone would be "categorized". Another possibility is that the phone might differ from all L1 phonemes, and thus it would be "uncategorized". The final option states that the phone might be assessed as a non-linguistic sound and thus "non-assimilated". The results of the assimilation phase then determine the learner's ability to discriminate L2 phones. The authors further define several assimilation combinations and assign them with successful discrimination probability. They speak about "Two Category" assimilation where two L2 phones correspond to two distinct L1 phonemes, resulting in a very good discrimination. Conversely, "Single Category" assimilation, where two L2 phones are categorized as instants of the same quality of one common L1 category, leads to a poor discrimination. "Category Goodness" then promises intermediate discrimination and refers to a situation when two L2 phones categorized as instants of a single category differ in their quality. "Uncategorized-Categorized" assimilation indicates that one L2 phone is identified as an L1 phone and the other L2 phone is not categorized, predicting a good discrimination. "Uncategorized-Uncategorized" assimilation takes place when two L2 phones are uncategorized leading to poor or intermediate discrimination. Final possibility is that the L2 phones are not identified as speech sounds and are "Non-Assimilable" and the discrimination then may vary.

2.4.2.1. SLM and PAM comparison

As SLM, Best and Tyler's (2007) PAM also assumes that in the course of life individuals continue to adapt their perception to new stimuli they are exposed to (to new dialects, a new environment, a new foreign language). However, these two models differ in the kind of information learners retrieve. PAM presumes that learners retrieve "invariants" regarding articulatory gestures, whereas according to SLM learners establish categories based on acoustic-phonetic aspects of sounds. It does not share the SLM's view that the phonetic categories are stored in the long-term memory and claims that learners become accustomed to articulatory gestures of the speaker, perceiving "invariants" regarding amplitude and articulation. Further, PAM stresses that it is not only phonetic level that is important for L2 learning and phone discrimination but phonological and gestural as well. Best and Tyler (2007) emphasize that the identification of phones as belonging to a phonological category takes place at the phonological level (level relevant for the distinction of meanings) implying that the phones in question do not need to be considered same at the phonetic level. That is in contrast with SLM, which presumes rather that both phonological and phonetic levels influence the identification of phones as instances of a certain category depending on the phonological organization of languages concerned. The authors then explain that even the phones judged to be in a single phonological category can, according to PAM be produced authentically assuming that they are successfully discriminated. As a consequence, learner's adaptation to the perception of the contrast within one category might lead to changes in characteristics of the phoneme for L1 and L2. In other words, the learner would establish two phonetic categories for one common phonological category.

2.5. Research findings

The following paragraphs will provide an overview of existing studies on L2 to L1 cross-linguistic interference.

2.5.1. Early bilingual studies

The findings on early bilinguals vary. Some studies found no or very limited influence of L2 on their L1 production, in other words, the bilinguals' performance did not differ from the performance of monolingual L1 speakers. These studies provide support for the view that early bilinguals can attain two independent language systems, provided that their L2 language performance is native-like as well. Such findings were observed e.g. in Mack (1989), Kang and Guion (2006) and MacLeod, Stoel-Gammon and Wassink 2009).

2.5.1.1. Early bilingual studies: no or limited L2 to L1 influence

Mack's study (1989) was one of the first studies on cross-linguistic influence dealing with early bilinguals. Mack compared speech perception and production of English-French bilinguals to English monolinguals to determine whether the bilinguals' phonetic systems are independent, finding only a few deviations from the monolinguals. Namely, differences were found in the perception identification test the aim of which was to identify a presented stimulus – /ta/ or /da/ sound in the first part and /i/ or /ɪ/ sound in the second part. It was revealed that, as regards the perception of /i/- /ɪ/, the bilinguals identified less sounds as /i/ than the monolingual controls. In the same identification test of English /d/ and /t/, bilinguals had a smaller number of steep identification function. Further, as regards the production, the only difference was that the bilinguals had a higher number of /i/ vowels with F2 decreasing from the midpoint to offset. However, in the overall view, there were only a very few significant differences between the early bilinguals and monolinguals in this study.

Further, studies conducted by Kang and Guion (2006) and MacLeod, Stoel-Gammon and Wassink (2009) found no significant differences between monolingual and bilingual speakers whatsoever.

Kang and Guion (2006) investigated the effects of the age of acquisition on the manifestation of cross-linguistic influence and the organization of bilingual's L1 and L2 systems. In their study, L1 Korean L2 English early bilinguals produced stops as monolinguals in both their languages. On the other hand, the late L2 English bilinguals differed from the English monolinguals in all explored aspects. Further, the late L2 English bilinguals produced longer VOT for L1 Korean fortis stops compared to Korean monolinguals. The analysis of all investigated aspects of stops revealed that early bilinguals established five different categories of stops in their vowel systems corresponding to existing types of stops in English and Korean. In comparison, late bilinguals formed only three different categories of stops: one common category for English voiceless and Korean aspirated stops, another common category for English voiced and Korean fortis stops and a separate category for Korean lenis stops. The study observed an effect of age on the occurrence of cross-linguistic interference. The early bilinguals managed to perform like monolingual speakers of both Korean and English, whereas the speech of late bilinguals manifested a bi-directional interference.

MacLeod, Stoel-Gammon and Wassink (2009) investigated speech production of bilingual speakers of Canadian French and English, the majority naming both their languages as their L1. The authors tested the validity of Flege's SLM, in particular, whether early bilingual speakers establish separate categories for similar vowels. The vowels in question were high vowels /i, ɪ, u, ʊ/ which all have a status of phonemes in English, whereas in French, only /i/ and /u/ are phonemes, the rest are allophones. The study confirmed differences between English and French speakers: French vowels being more peripheral, and the lax vowels having lower F1. The bilinguals followed this pattern in their productions of French and English and showed no significant differences from French and English monolinguals. Thus, the bilinguals showed monolingual-like production in both their languages, and in accordance with the Flege's (1995) SLM, they established separate categories for similar vowels.

2.5.1.2. Early bilinguals: L2 to L1 influence

Nevertheless, other studies reported contradictory results: thus, early bilinguals' L2 influenced their production in L1 (Harada 2003, Fowler et al. 2008, Baker and Trofimovich 2005, Yang and Fox 2017).

In Harada's study (2003) production of voiceless stops of native Japanese early bilinguals was affected by their L2 English. Although the early bilinguals seemed to establish two different categories for Japanese and English stops since they made a clear distinction between the VOT production in both languages and their VOT values for L2 English did not significantly differ from the monolingual speakers, their L1 values were somewhat affected by their L2 – they produced voiceless stops with longer VOT in Japanese in comparison to their monolingual counterparts. Harada explains the observed shift towards the English values as a means of maintaining contrast between stops in the two languages since utterance initial English voiced stops and Japanese voiceless stops occupy the identical acoustic space.

Fowler et al. (2008) report on simultaneous French-English bilinguals who manifested cross-linguistic influence in their production of voiceless stops. Although they had separate values for each language, in comparison to monolingual speakers, their VOT values were intermediate, indicating that language systems of bilinguals are not independent. In addition, it was tested whether a mere exposure to L2 (not learning or knowing it) could have an impact on its learning and on L1 production as well, however, no evidence to support this hypothesis was found when comparing speech of monolinguals from areas either with presence or absence of L2 speakers.

Baker and Trofimovich (2005) found the L2 into L1 interference to be dependent on the age of acquisition of L2, amount of L2 experience and cross-linguistic similarity. In their investigation of four groups of bilinguals differing in age of L2 acquisition and amount of L2 experience, late English-Korean bilinguals showed no differences from monolinguals in their L1 Korean speech performance, whereas a group of early experienced learners was affected by the L2 English. Nevertheless, the early group with less experience did not show any divergence from the monolingual norm.

The study focused on the production of six English (/i/, /ɪ/, /ae/, /ɛ/, /u/, /ʊ/ and five Korean (/i/, /ɛ/, /e/, /u/, /ɨ/) vowels which were chosen based on either their mutual resemblance or difference between them in the two systems. Data on speech production of monolingual Korean and monolingual English speakers showed that Korean /i/ and English /i/ occupied the same space in the vowel space, same applied to Korean /e/, /ɛ/ and English /ɪ/. In comparison, English vowels /ae/ and /ɛ/) did not share a vowel space with any Korean vowel. The situation was more complex in case of the English /u/, /ʊ/-Korean /u/, where there was a partial overlap (with differences based on age).

It was shown that the late bilinguals did not make a distinction between the English and Korean similar sounds in their production, they managed to maintain different acoustic properties only in case of dissimilar sounds. However, early bilinguals were successful in all instants (with the exception of vowels that occupied identical place in the vowel spaces). Further, for late bilinguals, the amount of experience did not make a difference, however in case of early bilinguals, more experience indicated ability to distinguish even perceptually confusing vowels such as English /u/-/ʊ/ and /ae/-/ɛ/.

In late bilinguals, the authors observed L1 to L2 interference the degree of which depended on the similarity of the particular vowel in the language systems – acoustically similar vowels /ɪ/, /ae/, and /ʊ/ were not produced authentically. However, there was no divergence from the monolingual norm in their production of Korean vowels, thus no L2 to L1 interference was observed.

The situation differed in case of early bilinguals. Even the group of early bilinguals did not match monolingual English speakers in production of some vowels (the same set as in case of late bilinguals). At the same time, Korean vowel system of experienced early bilinguals was affected by their L2 English in production of vowels /i/, /u/, and /ɛ/ but there was no L2 to L1 interference in speech of early learners with less experience.

Yang and Fox (2017) confirm the observation made by Baker and Trofimovich (2005), namely that the L2 to L1 interference seems to be manifested only in case of bilinguals experienced in their L2. In their research on production of vowels by Mandarin-English children with L1 Mandarin, they found out that children with less English experience produced Mandarin /a, i, u, y, ɤ/ vowels identically as Mandarin monolingual children. On the other hand, bilingual children with more experience showed different pronunciation of Mandarin vowels with phonetically similar counterparts in English /a, /i/, approximating the frequency of English vowels. In addition, the trajectory length of the vowel /i/ was shorter in comparison to Mandarin monolinguals, more English-like. In production of vowels with no counterparts /y/ and /ɤ/, they did not differ from monolinguals in formant frequencies, yet their formant movement might have been affected by English. Further, the less experienced children did not reach monolingual-like performance in their L2 English, whereas the experienced children did not significantly differ from the English monolinguals. These results suggest that less experienced children used L1 as a basis for formation of their L2 vowel system – English vowels were judged to be a part of existing L1 categories and no new categories were established whereas the experienced children established separate categories for each language.

As we have seen, the studies do not report identical results. They seem to indicate, that it is difficult yet not impossible for early learners to maintain monolingual-like pronunciation in both languages. At the same time, they provide evidence for the hypothesis that the language systems exist in a common phonological space and thus can influence each other (See Flege 1995, Best and Tyler 2007). For example, even Mack's (1989) study, which on overall provides support rather for independence of the phonetic systems, found subtle distinctions between monolinguals and bilinguals. Finally, the studies indicate that the degree of interference is determined by further factors such as the amount of experience with L2, age of L2 acquisition, and cross-linguistic similarity.

2.5.2. Late bilingual studies

Studies on late learners often explore L2 on L1 interference in terms of attrition (Bergmann et al. 2016, Major 1992, de Leeuw, Mennen, and Scobbie 2012, Stoehr et al. 2017). Bergmann et al. (2016, 72) define attrition as "…changes (usually a decline) in an individual's abilities in a language, induced by decreased use of and input in this language". Thus, research focus seems to be mostly on late learners who live in an L2 dominant country and gained L2 experience by immersion. Nevertheless, there are further branches of research, such as studies investigating short-term effects of learning an L2 on L1 (e. g. (Chang 2011, Schuhmann and Huffman 2015) and studies, which seem to be rather rare, investigating late learners in an L1 dominant environment (e. g. Schereschewsky, Alves, and Kupske (2017), as the current study.

2.5.2.1. Late bilingual studies: no or limited L2 to L1 influence

It has been proven that even late learners can experience L2 to L1 interference (Pavlenko 2000), yet it does not necessarily lead to a conclusion that this influence has to be manifested in speech of all late bilinguals. Although this paper aims to focus mostly on studies that have discovered bidirectional language interactions, and thus this section will be rather brief, to provide a more wholistic view on the matter, examples of studies which found no or very limited L2 to L1 influence will be mentioned in the paragraphs below.

A study conducted by Yeni-Komshian, Flege, and Liu (2000) explored validity of critical period hypothesis by rating speech of early and late bilinguals on their nativelikeness. The tested premise was that if the critical period is not a result of gradual cognitive changes, function of age and proficiency must be nonlinear and early learners unlike late learners should achieve native-like L2 pronunciation. At the same time, if the hypothesis is valid, L1 should not be affected by L2. The participants were L1 Korean bilinguals living in an L2 dominant environment who were divided into ten groups the basis of their age of arrival in the USA. Their speech production in both languages was assessed on the foreign accent degree by native monolinguals of each language. The results showed that even the earliest group of bilinguals differed from the English monolinguals. Further, the higher the age of arrival, the stronger was the accent, however, this increasing tendency ceased at the age of fourteen. The L1 production of most late learners was indistinguishable from the production of Korean monolinguals whereas the majority of early learners failed to reach the same ratings as monolinguals. More specifically, approximately half of the bilinguals did not perform as the Korean monolinguals. Although both early and late learners were affected by their L2, L2 to L1 influence was more substantial for early learners, which the authors explain as a possible result of changing the dominant language. Thus, overall results of the experiment showed only a limited support of the critical period hypothesis – namely, in the poorer English performance of the late learners.

The study by Yeni-Komshian, Flege, and Liu (2000) found only a limited L2 to L1 influence in case of late learners, since as a group they were rated the same in their L1 as monolingual speakers. The same results were obtained in a above discussed study on Korean-English bilinguals conducted by Baker and Trofimovich (2005), where it was only early learners who experienced L2 to L1 effects.

2.5.2.2. Late bilinguals: L2 to L1 influence

2.5.2.2.1. L2 environment (attrition) studies

Bergmann et al. (2016) investigated speech production of L1 German attriters with L2 English, namely the lateral approximant /l/ and selected group of vowels. The attriters were divided into two groups based on native-likeness ratings, on the grounds of hypothesis that the group with lower ratings will manifest greater influence of L2 English on L2 German. Attriters' L1 showed signs of being influenced by the L2 – higher-rating group produced /aː/ with lower F2 than the control group, thus reaching more English-like values. The same applied for the F1 of /l/ which was higher for the attriter groups than for the control group. However, there was no significant difference in the formant values of the remaining analyzed vowels, namely /ɛ/ and /ɔ/. The hypothesis on correlation of native-likeness ratings and changes in formant frequencies was not confirmed since whenever the lower-ratings group differed from the German monolingual control group, same applied for the higher-ratings group. Moreover, there were instances when higher-ratings group differed from the control group, but the lower-ratings group did not. Based on these findings, authors concluded that the reason for sounding non-native was most likely caused by different pronunciation aspects than by the change in formant frequencies of phones observed in this study. The study confirms that not all pronunciation aspects need to be influenced to the same extent (as we have already observed e. g. in Yang and Fox (2017).

The importance of L2 environment is emphasized in research conducted by Mayr, Price and Mennen (2012). The study investigated speech of monozygotic twin sisters with L1 Dutch and L2 English, one who stayed in L1 dominant environment (Netherlands), the other emigrated into L2 dominant environment (United Kingdom). The explored aspects were voiced and voiceless stops and Dutch vowels. The results showed that production of the twin who stayed in L1 environment did not significantly differ from monolingual Dutch speakers. On the other hand, the other twin produced Dutch voiceless stop VOT with values significantly higher. Her English voiceless stop production then shows that she adopted values intermediate to English and Dutch for both languages. In the production of Dutch voiced stops, however, she maintained a native-like performance. Moreover, her English voiced stops were even more pre-voiced than her Dutch ones. This finding is rather unexpected since, as the authors explain even if she developed separate categories for L1 and L2 phones, the shift would be more likely to take place in L2. Further, the L2 dominant twin's F1 was higher for the majority of explored Dutch vowels including Dutch vowels with no counterpart in English – front and rounded /y/ and /ʏ/.

However, Major's (1992) study shows that even daily use of L1 in an L2 dominant environment does not prevent from the occurrence of L2 to L1 interference. In his study, L1 English bilinguals with L2 Portuguese living in an L2 dominant environment manifested signs of attrition although they, as teachers of English, used their L1 on daily bases. The study further examined factors of L2 experience and stylistic variation on the degree of L2 to L1 interference. It was revealed that all bilinguals experienced attrition of L1 to some extent – all showed lower, more Portuguese-like, VOT values in their English production than the monolingual controls. Further, the degree of the L2 to L1 interference rose with the L2 experience and it appeared to be greater in casual rather than formal speech.

Similarly to Major (1992), a perception study conducted by de Leeuw, Schmid, and Mennen (2010) investigated a role that L1 contact has in preventing attrition in bilinguals living in L2 dominant settings. The authors further differentiated between L1 contact that may include code-switching and L1 contact in situations where code-switching would not be expected. The impact of factors such as length of residence and age of arrival was accounted for as well. The participants were L1 German late learners of English who emigrated either to Canada or the Netherlands and have spent there the minimum of nine years and a control group of German monolinguals. Their spontaneous speech production on a given topic was assessed by German monolingual listeners with at least some amount of phonetic training. As anticipated, as a group, bilinguals received higher foreign accent score than the monolingual control group. Although the L2 Dutch and L2 English groups did not diverge from each other in terms of accent scores, there were differences among individuals. However, there were individual differences: some bilinguals did not pass as native speakers, others were marked as native speakers, and a status of the rest was rated unclear. A correlation between the amount of code-switching-free contact with L1, and the native-like ratings was observed. The more of the "pure" L1 contact the participants had, the less foreign-accented their speech was, a tendency that applied especially to those who arrived to the L2 dominant environment at a later age.

Another study discussing the role of contact with L1 in attrition was undertaken by Stoehr et al. (2017). The study included late bilingual couples with different L1 residing in the Netherlands. In other words, bilingual participants formed two groups: a group of L1 German L2 Dutch bilinguals and a second group with the inversed order of acquisition of languages. The bilinguals encountered both Dutch and German at home, however, the L1 Dutch group had a greater exposure to their L1 given the participants' country of residence. In addition, two groups of monolinguals of respective languages participated as well. The participants completed a picture naming task in which they produced stop initial target words. VOT measurement revealed that in their L1, bilinguals produced VOT values intermediate to the values of the other bilingual group with reversed order of acquisition of languages and the corresponding monolingual group. Thus, overall, L1 Dutch bilinguals produced stops with longer VOT than Dutch monolinguals, indicating the influence of their L2 German – a language with the stop categories further to the right on the VOT continuum in comparison to Dutch, Dutch voiceless and German voiced stop categories overlapping. The same pattern applied to L1 German bilinguals who, presumably due to L2 influence, produced somewhat shorter VOT than the monolingual controls. Nevertheless, when investigated in a greater detail, there were further distinctions in production of the stop categories. The L1 German group experienced attrition of the voiceless stops but at the same time their voiced stops were not influenced by L2. It is necessary to point out that L1 German group failed to acquire native-like pre-voicing patterns in Dutch voiced stops although they produced more pre-voiced stops in their L2 Dutch than German. Similarly, L1 Dutch bilinguals succeeded to distinguish between their L1 and L2 voiceless stop categories (although not reaching native-likeness), yet they did not produce voiced stops in their languages differently. The authors thus argue that pre-voicing patterns may not be subject to attrition and pose an acquisition problem as well. In addition, even though the L1 Dutch group experienced L2 to L1 influence, they managed to keep native-like values in their L1 as opposed to L1 German group, indicating that L1 contact is necessary to be able to maintain the status of a native speaker.

Dmitrieva, Jongman, and Sereno (2010) observed that degree of interference increased with L2 proficiency. The authors studied bi-directional interference on neutralization of voicing of obstruents in a word-final position. The language pair studied was Russian and English. For Russian, final devoicing is reported, however, in English it does not occur. Phonetic aspects known to change with the final obstruent voicing were measured in the experiment: preceding vowel duration, closure or frication duration, duration of voicing into closure or frication, and duration of the release of the stop. Three groups of speakers participated in the study: a group of monolingual Russian speakers – to describe devoicing in Russian – and two groups of bilingual speakers, namely L1 Russian speakers of English and L1 English learners of Russian – to observe language interactions. The analysis of data collected in the word-reading task showed that L1 Russian L2 English bilinguals adjusted all the aspects in response to the voicing of the obstruent in the final position. Vowel duration and voicing into closure/frication was longer when the final obstruent was voiced (as opposed to voiceless) whereas closure/frication and release duration was shorter. Contrarily, Russian monolinguals regulated merely closure/friction and release duration. Further tests revealed that the amount of L2 experience predicted the degree of vowel duration differences: experienced L2 speakers produced more substantial differences than those with less experience. In addition, L2 experience had a significant role in the final obstruent voicing for L1 English learners of Russian as well. Although English-influenced learners Russian accommodated all the aspects according to voicing of final consonant, those with greater L2 experience decreased the degree of differences. Finally, the authors also noted distinctions in segment duration (both vowel and consonant duration) which may be attributable to phonetic interference. In comparison to monolinguals, Russian learners of English produced longer segments due to slower speech, however, as the authors note, this can be explained by a somewhat different experimental environments in which the groups were recorded as well.

A study conducted by de Leeuw, Tusha, and Schmid (2018) illustrates that attrition may lead to a complete elimination of a phonemic contrast. The authors investigated production of lateral approximant in the speech of ten L1 Albanian L2 English late bilinguals.

In Albanian, a clear as well as dark lateral approximant has a status of a phoneme and thus using one instead of the other would lead to a change of meaning. On the other hand, in Standard Southern British English, the clear and dark lateral approximants function as allophones of a single phoneme, occurring either in a syllable onset (clear /l/) or coda (dark /ɫ/) and having no meaning contrasting function. To distinguish between clear or dark lateral approximants, F2 frequency is commonly used since dark approximants are characterized by a considerably lower F2. It was presumed that bilinguals may produce Albanian dark /ɫ/ in syllable onsets with higher F2 and at the same time clear /l/ in syllable codas with lower F2 as a result of acquiring English. To be able to detect the changes, a monolingual Albanian group participated in the experiment as well. After collection of data consisting of clear and dark *l* contrasting minimal pairs, the recordings were both analyzed acoustically and evaluated by a group of monolingual listeners on their native-likeness. The monolingual native-likeness ratings showed that dark /ɫ/ in syllable onsets and clear /l/ in syllable codas were in a variety of cases judged as non-native whereas light /l/ in onsets and dark /ɫ/ in codas were always considered native-like. Acoustic analysis showed that the monolingual control group preserved clear /l/ and dark /ɫ/ distinction in terms of their F2. In contrast, bilinguals showed great individual differences with about half of them succeeding to perform as either clear monolinguals or with only very small deviations from the monolinguals' performance, as predicted by the perceptual evaluation. Two bilinguals failed to produce onset and coda clear /l/ in the same way, however, contrary to expectations, their coda clear /l/ was even clearer than in the syllable onset. Another two bilinguals produced a darker clear /l/ in syllable codas, minimizing the contrast between clear and dark l in syllable codas position. The same applied for the final participant of the study who in addition to darkening of the clear /l/ in syllable codas also produced clearer dark /ɫ/ in syllable onsets. Finally, clear /l/ in onset position and dark /ɫ/ in final position did not undergo any changes for any of the bilinguals, as expected by the authors based on its correspondence to the English norm.

2.5.2.2.2. Immediate effect studies

Further, there is some evidence that the L2 effect can manifest itself even after a relatively short learning time. Chang (2011) found that native English speakers at the end of an intensive six-week Korean course decreased F1 of all their vowels by almost twenty Hertz as a result of English influence, Korean vowels being on overall characterized by lower F1 and F2 than English vowels. As the author explains, the shift was systemic, not accumulation of individual assimilations of vowels since the shift of some vowels did not approximate

Korean vowels. However, the F2 of vowels did not change. According to Chang (2011), the explanation might dwell in a lower perceptibility of F2 or lower dispersion due to F1 shift.

Schuhmann and Huffman (2015) adopted a similar research approach and investigated whether an L1 of native speakers of English will drift as a result of learning French. Based on previous research, the authors assumed that the said L1 drift will take place and planned to explore whether perceiving L1 and L2 sounds as different is a sufficient criterion for an assimilation of L1 and L2 sounds to take place. In addition, authors studied the effect of formal phonetic instruction on the acquirement of L2 categories and on possible L2 to L1 interference. The examined aspect was VOT since stops in these two languages are situated on different places of the VOT continuum. The participants were recorded every even week in the course of their Spanish program. Between the sixth and the eighth week participants received phonetic s lessons on the production of Spanish and English stops. The results of the participants were rather individual. In the sixth week, pre-voicing typical for Spanish voiced stops started to be more common in participants' production of Spanish stops, indicating they noticed L1-L2 differences. This trend became even more apparent in the tenth week. However, the change of L1 voiced stops was apparent only in case of some speakers, when the weeks six and ten were compared. As regards the Spanish voiceless stops, the participants showed a statistically significant lowering to more Spanish-like values between the sixth and tenth week. The lowering tendency applied for English voiceless stops as well, although the difference did not reach a statistical significance. The authors concluded that phonetic instruction helped the participants to approximate to L2 categories, however, as they note themselves, the impact of experience and phonetic instruction cannot be easily distinguished without a control group. Finally, the L1 approximation to L2 phones applied only for some participants, suggesting that the perception of L1 and L2 differences does not necessarily lead to assimilatory shift.

Unlike in the two studies introduced above, where bilinguals' production was compared to that of monolinguals at different temporal points in the course of L2 learning, López (2012) compared bilinguals' production in a pure L2 setting and a code-switch setting. She observed speech of English-Spanish bilinguals, investigating whether and to what extent late learners of Spanish created new L2 categories. It was assumed that due to participants' intermediate Spanish skills, interference will be merely unidirectional from L1 to L2. In other words, the author did not presume the emergence of separate L2 categories but rather application of existing category for both languages. The observed categories were Spanish and English voiceless stops and the study included a total of three language conditions – the participants read monolingual English, monolingual Spanish, and code-switched sentences. In their Spanish production, the bilinguals managed to lower their VOT to more Spanish-like values, suggesting they created new L2 categories. The results showed that although the bilinguals' English values were corresponding to those of native English monolingual speakers, L2 to L1 interference nevertheless occurred. Namely, English voiceless bilabial and velar stops in code-switching condition differed from voiceless stops in the pure English condition. The production of the alveolar stop was not affected, presumably due to a dental place of articulation in Spanish. A VOT shortening took place for bilabial stops occurring before the Spanish part of the sentence, possibly in preparation to produce the L2. The same tendency was visible even in case of velar /k/, however, it took place even after the code switching in the opposite direction – after the Spanish part. The explanation provided is that Spanish served as the main language that merely incorporated the English part and thus governed the production of English /k/.

2.5.2.2.3. L1 environment studies

Below presented studies conducted indicate that L2 to L1 interference can take place even in L1 dominant environment. For example, Schereschewsky, Alves, and Kupske (2017) measured VOT of plosives /p/, /k/, /b/, /g/ in speech of two groups of L1 Portuguese bilinguals with L2 English divided into two groups divided according to L2 proficiency. The results showed that the L2 to L1 interference took place only in case of a consonant /k/ since its higher VOT values resembled English. No differences in Portuguese production were found between the B1/B2 and C1/C2 group of learners. These results were further interpreted in relation to the bilinguals' English production which reveal that /k/ was the only vowel in which the attrition could have taken place since the bilinguals approached the native speakers in its pronunciation. In case of /p/, although the bilinguals had separate values for English and Portuguese, their English values did not resemble the native-speaker values. As regards the voiced plosives /b/ and /g/, bilinguals seemed to simply adopt their L1 production pattern. Finally, there was no significant effect of proficiency on the L2 production, if anything, the B1/B2 learners outperformed the C1/C2 group, possibly indicating an unsuitability of the proficiency assessment test. Nevertheless, the results provided some support to the mutual dependability of bilinguals' language systems.

Kim (2011) also explored interference in an L1 dominant setting, namely the impact of proficiency on the direction of interference. In her pilot study, she chose to compare the production of voiceless stops of L1 Korean late learners of English whose L2 proficiency greatly varied. Although both Korean and English have a category of voiceless aspirated stops, the VOT of Korean aspirated stops is considerably longer, although in the recent years a shortening tendency has been reported. The participants' English speech production was compared with that of native English speakers. The results showed that on average, Korean learners of English had lower VOT values than the native speakers, however, there were differences according to proficiency. Namely, the most experienced L2 learners approximated the native speakers, the least experienced produced stops with longer VOT, and the intermediate learners displayed even shorter VOT than native English speakers. As regards the production of Korean stops, more proficient speakers tended to have lower VOT as opposed to the less proficient speakers, indicating that learning L2 influenced their Korean stops. In addition, for most Koreans, their L1 VOT values were even lower than L2 values. However, in order to be able to observe the interference and its directionality in a greater detail, it may be advisable to assemble a monolingual control group.

Mennen's study (2004) then shows that interference manifests itself even at the suprasegmental level. Mennen explored intonation of L1 Dutch late learners of Greek. She investigated the pattern of pre-nuclear rise in declarative intonation. In both Dutch and Greek, this pattern is characterized as a sequence of low and high tones in both languages. However, the timing of the peak of these tones differs (it is earlier in Dutch) and in Dutch it is further influenced by vowel length of accented syllable. The results showed that the majority of native Dutch learners of Greek placed the peak of the high tone earlier than native Greek speakers. At the same time L2 Greek influenced the majority of bilinguals in production of L1 Dutch as well, showing a bidirectional interference. The bilinguals showed a trend towards neutralizing differences of the timing – in Dutch governed by the vowel length of accented syllable. However, one of the participants was able to maintain native-like intonation in both languages. Thus, the results indicate that the occurrence of bi-directional interference in intonation patterns is likely yet not inevitable.

2.5.3. Summary

Although presented studies were divided into categories for better orientation, their categorization is not always clear-cut, since some of the discussed studies deal with both early and late learners (e. g. Baker and Trofimovich 2005; Yeni-Komshian, Flege, and Liu 2000), their results may be interpreted as both denial of and support for L2 to L1 interference (e. g. Yeni-Komshian, Flege, and Liu 2000), or detailed characterization of participants that may be useful for further classification is not provided. Based on information gathered from the studies, it seems that several factors may predict likelihood of occurrence and the degree of L2 to L1 interference. Namely, age of onset of learning, L2 experience (proficiency), amount of L1/L2 contact, and the similarity of investigated features in L1 and L2.

2.5.3.1. Age of onset of learning

According to the premises offered by Flege (1995), mechanisms that apply in L1 learning are still applicable in L2 acquisition and one's phonetic system keeps adapting to new sounds the whole life, a view that is shared even by Best and Tyler (2007), thus the above presented findings of interference in speech of both early and late learners may be expected. Yet, some studies found differences when comparing groups with different age of onset of learning. Studies by Baker and Trofimovich (2005) and Yeni-Komshian, Flege, and Liu (2000) found L2 to L1 influence only in case of early but not late bilinguals. That is in accordance with a view presented by Yang and Fox (2017), those who learned L2 at an early age did not have a fully developed L1, thus more substantial changes of their L1 may be expected. Flege's (1995) SLM also provides support to this view since it presupposes that speech perception is accommodated to established L1 categories, so the later a person acquires L2, the more difficult it may be to perceive subtle differences between L1 and L2 phones. Therefore, it may be harder to establish new categories for L2 sounds, and as a result, L1 sound characteristic could be applied when producing L2 sounds as well. However, opposite results were obtained by Kang and Guion (2006) where it was early bilinguals who managed to obtain two seemingly independent systems and late bilinguals who seemed to merge categories in their L1 and L2, a phenomenon which is discussed in Flege (1995) as well by an equivalence classification, according to which similar L1 and L2 sounds may joined in a single perceptually intermediate category. Therefore, it seems that a factor of age of L2 acquisition by itself cannot reliably predict occurrence of interference, or its direction, and other factors need to be taken in consideration as well.

2.5.3.2. L2 experience

It seems that L2 experience, which may be in some studies used interchangeably with length of residence in an L2 country, often correlates with the manifestation of interference. As Piske, MacKay, and Flege (2001) denote, both length of residence and amount of formal instruction may lead to a decrease of a foreign accent degree, thus L1 to L2 interference. Conversely, it could be argued that both of these factors could predict occurrence and degree of L2 to L1 interference as well: those with more L2 experience may be more likely to have

L1 speech affected by L2. Piske, MacKay, and Flege (2001) further warn that the age at the onset of learning was proven to be a greater predictor than experience and that a higher amount of experience (or length of residence) did not always result in a weaker accent. Yet, they admit that for late learners the difference between a year or less of L2 experience and several years of experience was rather significant, which could mean that the amount of experience may have a significant role in occurrence of L2 to L1 interference in case of late learners, if not early learners. In addition, the authors are rather skeptical as regards the role of formal instruction since its contributions to decreasing of the foreign accent degree were debatable. However, as they explain, the reason behind this is most likely a lack of phonetic training in classrooms, since improvements in L2 pronunciation have been reported as a result of such a training. Nonetheless, more experience and training should lead bilinguals to notice L1 and L2 differences, and consequently to an accommodation (or to a better accommodation) of their phonological system to L2 sounds, as discussed by Flege (1995). The validity of experience as a factor predicting L2 to L1 interference was confirmed in several studies discussed above, in case of both early and late learners. L2 to L1 interference in speech of early learners was conditioned by L2 experience in studies conducted by Baker and Trofimovich (2005) and Yang and Fox (2017). Same was reported for late learners in studies conducted by (Kim 2011), Dmitrieva, Jongman, and Sereno (2010), Schuhmann and Huffman (2015). Surprisingly, Schereschewsky, Alves, and Kupske (2017) reported no differences in degree of L2 to L1 interference based on proficiency. However, the authors also noted that since it may be said that the group with lower proficiency performed somewhat native-like in their L2, the method for determining proficiency might have been unsuitable.

2.5.3.3. Amount of L1/L2 contact

Attrition studies provide interesting observations regarding the contact with L1 and L2 and its impact on occurrence and direction of the interference. As seen in the literature discussed above, extensive contact with L2 can lead to attrition of L1. A study by Mayr, Price and Mennen (2012) illustrated the L2 contact significance especially well since the participants in their study were twin sisters with very similar linguistic background approximately up to the age of thirty. After that, probably the most-significant variable that changed was the amount contact with L2. Consequently, the twin with more L2 exposure experienced L1 attrition. As it was seen, attrition or L2 to L1 interference does not have to manifest in speech of all bilinguals equally. Research indicates that L1 contact may ensure preservation of native-like performance as observed e. g. in Stoehr et al. (2017). where those bilinguals with more L1 contact kept native-like pronunciation even though they were influenced by their L2 to some extent. A contradictory finding was reported by Major (1992) where a daily use of L1 did not stop attrition. A study conducted by de Leeuw, Schmid, and Mennen (2010) provides further suggestion, namely that it is not just L1 contact, but pure L1 contact without code-switching that is needed to prevent L2 to L1 interference from occurring.

2.5.3.4. Similarity of investigated features

As Baker and Trofimovich (2005) point out, similarity of L1 and L2 sounds may predict both successful L2 production of sounds in question and the degree to which L1 is influenced. In the study, their hypothesis that similar sounds will interact more substantially was confirmed, especially for late learners. Similar suggestions were made by Best and Tyler (2007) as well, who elaborated on potential difficulties in perception of L2 sounds based on L1 and L2 relation between the sounds in question (See the section Perceptual Assimilation Model). Not only study by Baker and Trofimovich (2005) observed similarity of sounds to have an effect on the occurrence of L2 to L1 interference, Yang and Fox (2017) reported production of vowels with similar counterparts to be affected by L2 but not vowels with no counterparts. Bergmann et al. (2016) also reported variation in the L2 impact on different vowels. Schereschewsky, Alves, and Kupske (2017) provide an explanation to their observation that only an L1 stop /k/ was subjected to interference since the production of the corresponding L2 vowel was mastered by the bilinguals, as opposed to the rest of the vowels. On the other hand, in Mayr, Price and Mennen (2012), the attrition experiencing bilingual produced even L1 vowels with no L2 counterpart in a manner different from her monolingual-like twin.

3 Present study

As illustrated in the literature review, studies investigating both perception (e. g. Yeni-Komshian, Flege, and Liu (2000) and production (e.g. Stoehr et al. 2017) indicate that the interference is bidirectional, although L2 to L1 effects do not have to manifest in case of all bilinguals, as it was observed e. g. in Mennen's study (2004) where one participant kept a native-like intonation in both L1 and L2 whereas the four remaining experienced bi-directional interference. In addition, a language background of the participant with the interference-free performance did not differ substantially from the rest, although it might be noted that this participant's age of both first and formal exposure to L2 was the lowest.

Further, it has been shown by de Leeuw, Tusha, and Schmid (2018) that the degree of interference can be so substantial, that even a phonological contrast disappears. The study thus supports Flege's (1995) view on the interaction of L1 and L2 sounds. It indicates that the perceptual link is not based on abstract level of meaning distinguishing sound categories but rather on level of their particular realizations in phonetic contexts.

Even though interest in studies which observe L2 to L1 interactions appears to be substantial, there still exists a somewhat less explored research area. As seen in the Research findings section, the vast majority of reported studies either focus on early learners (children – see also Pavlenko 2000), or on both early and late learners who experienced attrition after living in an L2 environment for a significant period of time. A branch of studies also investigated learners who just started learning their L2. Since these learners are at the beginning of the learning process, it could be argued that, unlike attriters, they did not have enough time and exposure to L2 to establish new categories for L2 sounds and are accommodating their L1 categories to L2 sounds by including the similar L2 sounds into an already existing L1 category, or in the middle of the process of creating new L2 categories (Flege 1995).

It seems that the research rather neglects investigating L2 learners who reside in an L1 dominant country and learned their L2 predominantly through formal instruction in schools, although exceptions have been discussed above as well. For example, López's study (2012) focuses on intermediate learners' speech production, however, the participants' performance is not compared to that of a monolingual control group. Instead, bilinguals' performances in two different experimental conditions are compared to each other: pure Spanish and two code-switching conditions. Therefore, the authors may be discussing short-term, momentary L2 to L1 interference, rather than long-term effects. Similarly, Kim's (2011) pilot study also lacks a comparison to a Korean monolingual group and the bilinguals' performance is merely compared within the group itself.

On the other hand, Mennen's (2004) study includes both L1 and L2 control groups and it most likely belongs to the studies dealing with bilinguals in L1 dominant environment, however, it does not seem to discuss whether the language experience was gained merely in L1 environment or if the speakers lived for a substantial time abroad. A study that is probably the most comparable to the present one is that of Schereschewsky, Alves, and Kupske (2017). Although a precise age of acquisition of L2 is not discussed, the authors note that the participants grew up in an L1 environment and developed their L1 there, suggesting they are late learners. A possibly somewhat problematic aspect of the study may be that the age range of participants is rather wide. There is a difference of 35 years between the youngest and the oldest participant. Further, since the bilingual participants were students in the first semester, it may be presumed that this group's age was rather homogenous, and that the age differences might have been greater between monolingual and bilingual group. That may possibly have some effect on the results, assuming the age differences between groups were truly substantial, since as Hawkins and Midgley (2005) illustrated in their study on vowel production in different age groups, speech develops over time.

3.1. Purpose of the study

The present study aims to investigate whether L2 will affect L1 Czech of Czech-English bilinguals who, as in Schereschewsky, Alves, and Kupske (2017), learned their L2 in L1 dominant environment through formal instruction. Thus, speech production of a bilingual group will be compared to that of monolingual speakers in order to see whether the interference will take place even in L1 dominant environment. It is possible the interference will occur in speech of the present group of bilinguals since they are experienced English speakers who study interpreting and translation major at a university and by nature of their major should have contact with both their L1 and L2.

Further, if L2 truly proves to influence L1 performance of the bilinguals, a further question that arises is that of nature of the effects. As Yang and Fox (2017) discuss, and as illustrated in the section Research findings, there are two kinds of effects which might be expected to occur: assimilatory and dissimilatory. As Flege (1995) elaborates, an assimilatory effect may take place when bilinguals use only one category for L1 and L2 sounds. Factors increasing the likelihood of this merge of properties of sounds in questions are e.g.: a later age of acquisition or a higher similarity of sounds. Nevertheless, the establishing of separate L1 and L2 categories does not seem to exclude a possibility of assimilatory effects manifestation (as illustrated e. g. by Yang and Fox 2017). At the same time, both Yang and Fox (2017) and Flege (1995) predict the occurrence of dissimilatory processes the purpose of which is preserving the contrast between bilingual's L1 and L2 categories in cases when new categories for L2 sounds have been established by bilinguals.

As mentioned above, both age of onset of learning and similarity of sounds is said to increase difficulty of establishing new categories. At the same time, between L1 sounds with a similar L2 counterpart we might expect a higher degree of interference (Baker and Trofimovich 2005). Therefore, L1 and L2 sounds that are hypothesized to be perceived as similar were chosen to investigate interference. Namely, Czech and English voiceless stops /p, t, k/ and English back vowels and Czech back (and central) vowels that were assumed to be equivalent: short Czech /u, o, a/ and English lax /ʊ, ɒ, ʌ/ and long Czech /uː, oː, aː/ and tense English /u, ɔ, ɑ/ (respectively).

Finally, in addition to investigation whether there is a long-term stable effect on bilinguals' L1 due to their acquisition and use of L2, this study is also interested in possible short-term L2 to L1 effects, assuming the bilinguals manage to produce selected vowels and consonants in their languages differently. As Grosjean and Li (2013, 14–18) explain, bilinguals can activate their languages to a different extent based on the circumstances. Thus, if a situation requires only one of the languages, such as being in an L1 country and speaking to an L1 native speaker about whom is known that he or she cannot use any other language, there is no need for activation of bilingual's other language. When an L2 is not needed, it is according to Grosjean deactivated and the bilingual is in so called monolingual mode. On the other hand, if a bilingual is e. g. attending a language lesson in which both languages tend to be used, both languages are activated, and the bilingual finds himself or herself in a bilingual mode. Usually, one language is more active and serves as a base language, however, bilinguals can switch between the base as needed as well as move along the activation continuum. In special circumstances, both languages can be activated to the same extent, and an example of that is interpreting.

It might be hypothesized that a higher level of activation of L2 at a given time may lead to more substantial effects on L1. Thus, in addition to comparing performance of monolinguals and bilinguals in a monolingual mode in which the bilingual's L2 should be deactivated to see if there is a stable effect of L2 acquisition, short term effects of a higher activation of L2 on L1 performance will be investigated as well, namely through an interpreting task.

To summarize, the study firstly aims to see whether the Czech-English bilinguals produce selected corresponding features in their languages differently, in other words, whether they created new L2 categories for investigated sounds. That will be assessed by examining their production in English and Czech. The second aim is to observe whether L1 investigated features will be influenced as a result of proficiency in L2 English, and if so, whether their voiceless stops /p, t, k/ and back and central vowels /u, uː, o, oː, a, aː/ come to resemble English /p, t, k/ and /ʊ, u, ɒ, ɔ, ʌ, ɑ/ (respectively) or if rather they move away from these phonemes. To find an answer to this question, bilinguals' speech production will be compared to the speech of functional monolingual speakers. The final aim is to see whether bilinguals' production in one language shifts as a result of a higher level of activation of their other language. This will be investigated by comparing bilinguals' production in a monolingual task to a bilingual interpreting task in both bilinguals' languages.

Consequently, the bilinguals will participate in the total of four experimental conditions: English only condition, Czech only condition, interpreting from English to Czech, and interpreting from Czech to English condition.

3.2. Methodology

3.2.1. Stimuli selection

For each studied vowel were chosen five words containing the vowel, that means that both for English /u, ʊ, ɔ, ɒ, ɑ, ʌ/ and Czech vowels /u, u:, o, o:, a, a:/ there was a total of 30 target words. The same principle was applied for voiceless stops /p, t, k/, resulting in 15 target words for each language. Further, 30 distractors were selected to prevent the participants from reveling which features were investigated, as it is a common practice (e. g. Hawkins and Midgley 2005; de Leeuw, Tusha, and Schmid 2018; Mayr, Price, and Mennen 2012).

The target words were either monosyllabic or disyllabic words carrying stress on the first syllable, the disyllabic words prevailing among the Czech targets. Since the experiment included not merely repetition tasks, but also interpreting tasks, the selection of words was limited not only by the desired immediate phonetic context of the examined vowels and consonants but by translatability and frequency of the words as well. The frequency of selected target words was reviewed with the help of the Corpus of Contemporary American English (Davies 2008-) and Czech corpus Český národní korpus (Křen et al. 2015), using the application KonText (Machálek 2014) for the search in the Czech corpus. A minimum of 10 occurrences (lemma) per a million of words was stipulated as an approximate boundary, however, there were several exceptions from this rule. The exceptions were, for example, Czech /o:/ vowel words. The reason behind this is that /o:/ vowel is not an original Czech vowel and occurs only in borrowings (Palková 1994, 196) so that it can be expected that the frequency of such words in the Czech corpus will be lower on overall. Further, a criterion for a frequency boundary might seem rather low, since some studies considers a high frequency 100 occurrences per million (Gierut and Dale 2007, Brysbaert, Mandera and Keuleers 2018). Nevertheless, as Brysbaert, Mandera, and Keuleers (2018) point out, low frequency words are typically defined as having less than 5 occurrences per million, leaving the stipulated boundary within an average frequency area. In addition, it was assumed that the interpreters have a fairly wide lexicon since in order to be able to interpret successfully, a high English proficiency is needed.

Further, the target words were selected with the aim to exclude Czech-English cognates so that the experiment could not be affected by activation of the other language triggered by the cognate status of the words (Brown and Amengual 2015). However, as discussed above, this rule was not possible to keep in case of Czech /o:/ vowel.

3.2.1.1. Phonetic context of vowels

For the purposes of as unambiguous segmentation of the vowels as possible, the immediate phonetic context of vowels was formed mostly by obstruents, in Czech words, a lateral approximant /l/ (initial position) and a fricative trill /r/ appeared as well. Moreover, voicing of the following consonant was considered in the selection of English stimuli. As Skarnitzl and Šturm (2016) explain, while in Czech the word-final voiced obstruents undergo devoicing and are pronounced identically as voiceless obstruents, English is characterized by so called pre-fortis clipping. Rather than preserving full voicing of the voiced word-final obstruent, English makes use of the preceding vowel and devoices the obstruent, either partially or completely. As a result, vowels before voiced obstruents have a longer duration than vowels before voiceless obstruents. Therefore, in the target word selection, there was an effort to counterbalance the voiced/voiceless obstruent distribution although it was not always possible. Nonetheless, since the purpose of the experiment is to investigate the quality of vowels rather than quantity, a somewhat unequal distribution of the voiced/voiceless obstruents should not be an issue.

3.2.1.2. Phonetic context of voiceless stops

The initial voiceless plosives were followed by a variety of vowels and diphthongs, with the exception of high vowels, which were excluded from occurring immediately after stops. The vowel/diphthong context of each Czech stop /p, t, k/ was matched in height to the context of each corresponding English stop. Moreover, the context was matched as much as possible among the stops in each language as well. The reason behind exclusion of high vowels and height matching are observations that vowel context affects VOT length, as discussed in the section on Variation in VOT in greater detail (e. g. Nearey and Rochet 1994).

3.2.2. Participants

3.2.2.1. Functional monolingual group

As Najvar (2008) notes, in the Czech Republic, learning a foreign language is since 2007 compulsory for pupils of the third grade of the elementary school, and even in the 1990s, the pupils had to start learning a foreign language in the fifth grade the latest. In his research including roughly 200 pupils from seven different schools, conducted between 2005 and 2006, he reports that in the third grade, about a half of the students learned English as a foreign language. Further, as (Ježková 2011) notes, in the Czech Republic, there is an emphasis on acquiring proficiency in foreign languages, especially in English. For that reason, it is rather impossible to find purely monolingual participants who would at the same time match or at least approximate the bilingual group in age and attained education.

MacLeod, Stoel-Gammon and Wassink (2009) describe their functionally monolingual group as having some experience with a second language but using it only sporadically. Similarly, the goal of the present study was to find speakers who would identify themselves as having only a limited L2 proficiency and the lowest use of and contact with L2 as possible. The total of 12 Czech native speakers agreed to participate in the research: 2 male and 10 female speakers. Their age ranged from 20 to 29 years (mean age: 23.2). Based on a self-evaluation language questionnaire, all have been exposed in the past to at least one more language other than English. However, with the exception of one participant who was a pre-intermediate speaker of Russian, all described themselves as beginners or complete beginners. All participants graduated from the secondary school and successfully completed school leaving exam, in addition one of the participants has a university degree. They started receiving formal English instruction when they were 11 years old the latest. A half of them reported having additional English instructions outside the classroom in the past, however, only two participants were attending English courses at the time of data collection (compulsory courses at the university). As regards the contact with English, the participants were asked how often they encounter with English texts, hear English in the media, communicate with speakers of English and write English texts. The majority replied that they (almost) never write English texts and communicate with speakers of English, whereas the answers to the remaining questions varied.

Speakers were also asked whether they would be able to help a native English speaker if they were asked for directions. Although 10 out of 12 participants said they would be able to explain the directions, the most of them added that this communication would pose a problem for them. Further, the participants were asked to self-rate their L2 competence on a 7-level scale, namely listening, reading, speaking and writing competence. The number 1 corresponded to the lowest degree (e. g. *I don't understand written English texts at all or almost at all*) and 7 to the highest degree of competence (e. g. *I understand written English texts perfectly*). The average self-ratings (rounded to one decimal place) are following: 3 for listening, 3.7 for reading, 2.4 for speaking and 2.1 for writing. Finally, more than a half expressed a desire to improve in English but only two stated that they are actively trying to improve via self-study. For a more detailed overview, see the Appendix where information about the participants collected through a questionnaire are translated into English and presented in several tables, namely, Table 11, Table 12, and Table 13.

3.2.2.2. Bilingual group

The participants were 10 students of a Master degree course in interpreting and translation at the Palacký University, either in their final year or extending their study period. All were females whose age ranged from 24 to 27 years (mean age: 25.5). Nine were native Czech speakers, one was a Czech-Polish simultaneous bilingual. In addition to L2 English, three reported to be fluent in one other language, which, according to the age at the start of learning, was their L3. Further, all three reported using their L3 only several times a year and passively encountering it for several hours a month or even less often. Only the Czech-Polish simultaneous bilingual reported using their L1 Polish several hours a week and encountering it on daily basis. All participants started learning English in fourth grade the latest, which corresponds to ages 9 to 10, some participants were exposed to English even in the kindergarten (ages 4 to 6). However, it would probably not be suitable to consider this age as the age of acquisition. Therefore, the bilinguals were asked at what age they were comfortable using English, which is considered as the approximate age of acquisition in this study. In addition, none of the participants spent a significant period of time in an English-speaking country before the age of 15.

Only a minority of bilinguals attended elementary or secondary school with extended English language instruction. On the other hand, six admitted receiving additional instruction in English, such as conversation lessons with native speakers, English summer camps, and additional language courses. However, only three participants were taught by a native speaker apart from their university studies. A half of the participants spent several months (ranging from 3 to 10) in an English-speaking country after the age of 15. As regards the L2 contact, most bilinguals reported being exposed to English in the media daily, whereas frequency of the interactions with native English speakers varied and was much lower than bilinguals' exposure to the English in the media. In addition, to have more information on their English proficiency, participants completed a vocabulary assessment test created by Nation and Beglar (2007), the results of which are presented in the Table 4 on the following page. As Nation and Beglar (2007) note, 8 000 word families should be sufficient to understand a variety of both written and spoken texts. For a further comparison, a non-native speaker studying a doctoral degree in English knows approximately 9 000 word families.

Participant	Number of Word Families
P1	10 500
P2	10 800
P3	9 900
P4	12 900
P5	12 200
P6	9 500
P7	13 700
P8	9 000
P9	10 400
P10	9 800

Table 4: Vocabulary assessment

The table shows results of a vocabulary assessment test (Nation and Beglar 2007) the participants were asked to take.

The participants were also asked about their interpreting experience. All took at least five courses of interpreting, an average per a participant ranges between eight and nine courses. Most participants further reported having experience with interpreting outside the university. On the other hand, the questionnaire showed that the bilinguals do not interpret very often these days, the majority answering that they interpret only several times a year or almost never. A half expressed a wish to improve their interpreting abilities but only one person stated an active effort to improve.

Finally, bilinguals were asked to self-rate their English accent on a scale 1 (*none*) to 7 (*heavy accent*), the average reported accent was 3.8 (3 – *light*, 4 – *some*) but the results varied: two participants reported 6 – *considerable* accent , two reported 5 – *moderate*, four reported 3 – *light*, and finally, the rest reported 2 – *almost none*. They also rated to what extent they find improving their pronunciation important on a scale 1 (*not important*) to 7 (*very important*). The average of 5.7 indicates that most would welcome improving their pronunciation. An additional 7-point scale, in which bilinguals rated whether they actively work on improving their pronunciation (1 – *not at all*, 7 – *immensely*) also suggested that they at least partially actively work on improving their pronunciation since their average rating was 4. For a more detailed description of bilingual participants, please see Appendix which provides answers to a bilingual questionnaire presented in tables, namely, Table 14, Table 15, Table 16, and Table 17.

3.3. Procedure

The recording sessions were held in the course of academic year 2019/2020 in acoustically suitable recording studios with the ZOOM H4nex recording device (sampling frequency 44.1 kHz). Participants were presented with pre-recorded sentences containing target words in a sentence final position and their task was to repeat or interpret these sentences with a use of an introductory frame. The used frames were borrowed from a study conducted by Šimáčková and Podlipský (2015). The employment of a frame and thus delaying repetition should stop the participants from merely imitating the sentences using sensory memory (Flege, Munro, and MacKay 1995). Thus, as in Šimáčková and Podlipský (2015, 2) the participants were presented with a sentence e. g. *Complete the second task,* and a subsequent frame eliciting question *What did you hear?* And the participants either repeated or interpreted the sentence depending on the particular experimental condition using a frame responding to the question e. g.: *I heard: Complete the second task.*

As mentioned in the section Purpose of the study, there was a total of four experimental conditions, English monolingual condition (EN only mode), Czech monolingual condition (CZ only mode), bilingual condition of interpreting from Czech to English (CZ to EN mode), and a bilingual condition of interpreting from English to Czech (EN to CZ mode) – for more on monolingual and bilingual conditions, see Grosjean and Li (2013, 14–18). For each of the conditions corresponding frame was used, always in the language that was supposed to be elicited from the participants. In other words, in interpreting from Czech to English condition, the Czech sentence was followed by an English question and the participants answered using an English frame and interpreted the Czech sentence into English. An overview of used frames in each of the conditions is presented in a Table 5 on the following page. All the stimuli (sentences and frames) presented to participants were recorded beforehand by two native speakers of Czech and two native speakers of English.

Condition	Question	Answer frame
EN (monolingual)	What did you hear?	I heard:
CZ (monolingual)	Co jsi slyšel? [What did you hear?]	Slyšel jsem: [I heard]
Interpreting (EN)	What should you say?	I should say:
Interpreting (CZ)	Co teď povíš? [What will you say now?]	Teď povím: [Now I will say]

Table 5: Overview of used frames in different experimental conditions

Frame eliciting questions and answer frames were borrowed (and somewhat adapted) from a study conducted by Šimáčková and Podlipský (2015, 2).

The bilinguals were recorded in two sessions, Czech session which included CZ only and CZ to EN condition and English session which consisted of EN only and EN to CZ condition. The reason behind the two recording sessions was the aim to ensure that both EN only and CZ only conditions are as monolingual as possible (See Grosjean and Li 2013, 14–18). For the same reason the sessions were always initiated by a monolingual condition so that the participants' speech production would not be affected by activation of both languages after interpreting. For that purpose, the English session was recorded by a different instructor – a university teacher and researcher – than the Czech session which was recorded by a university student. It was presumed that participants would associate the teacher with English context since they may have attended her in English taught lessons and that the more formal context would prevent them from switching to Czech. Further, the sessions took place on different days. However, there was one participant (P3) in whose case it was not possible to follow the above described rules due to the lack of participant's time available. This participant was recorded in one day by the student instructor with a small break between the two sessions.

At the beginning of each recording session, the instructor firstly explained the procedure and the participants demonstrated their understanding of the procedure in a short trial before the actual recording. The language of instruction corresponded to nature of the session – in the English session, English was the language of instruction, in the Czech session, Czech was used. Further, before the commencement of the English only condition recording, the instructor conversed with participants in English to activate the English monolingual mode. After the monolingual condition (either Czech or English, depending on the session), a priming task was administered to the bilinguals before the interpreting session. In the priming tasks, participants were presented with sentences containing target words and distractors. The sentences were written in pairs, one sentence was grammatically correct, the other contained a mistake. The participants were asked to mark the sentence containing a mistake. As stated in Pace-Sigge (2013) the activation of a certain construct, that is priming, leads to a greater accessibility of a given construct in one's memory. Therefore, the purpose of priming was to make target words more accessible in participants' mind and to increase probability of using target words in interpreting tasks.

For illustration, the course of the English session was following: short conversation in English with the instructor, trial of the EN only condition, recording of the EN only condition, priming task based on finding mistakes in Czech sentences, trial of the EN to CZ condition, recording of EN to CZ condition. The Czech session was conducted analogically. The order of the sessions was counterbalanced: half of the bilinguals started with the English session, the other half with the Czech session. In addition, at the end of the Czech session, bilinguals were asked to fill out a vocabulary assessment test (Nation and Beglar 2007). Therefore, the length of sessions differed: the English session took approximately 50-60 minutes, whereas the Czech session took about 75-90 minutes, depending on the pace of individual participants. Since the functionally monolingual group participated merely in the CZ only condition, their recording time was considerably shorter and took approximately 25 minutes. In addition, all participants were asked to sign a consent form, agreeing to participate in the research, which is enclosed in the Appendix.

3.4. Data analysis

3.4.1. Marking VOT boundaries

VOT was measured manually in Praat (Boersma and Weenink 2019), the boundaries, that is the release of the stop and the onset of voicing (Ladegfoged and Johnson 2011, 151), were determined in accordance with the recommendations on phonetic segmentation introduced by Machač and Skarnitzl (2009). The segmentation followed their main three principles. The first principle is placing boundaries next to "formant columns" Machač and Skarnitzl (2009, 23), which are described as vertical dark lines reflecting the acoustic energy peaks caused by the vocal cord vibration. Further, if a clear-cut establishment of boundaries is not possible, as it is in case of acoustically poorly contrasted "transition area" in the spectrogram, the boundary is placed in the middle of the said area (Machač and Skarnitzl (2009, 24). The final principle concerns the waveform and lies in placing the boundaries at the "zero crossing", a point when the sound wave meets the axis of the amplitude (Machač and Skarnitzl 2009, 24).

The authors (Machač and Skarnitzl 2009, 27–55) further elaborate on the segmentation of stops that are followed by vowels, as the word-initial stops in the present study. As indicated above, the following vowel is recognized by the presence of full formant structure so that the end of the stop should be marked left of the first clear formant column. Possible instances of transition areas, when the boundary should be placed in the middle, are enlisted. Namely, long and gradual decomposition of the formant structure, poorly distinguishable formant columns, overlap of formant structure and noise. Those cases, however, are more frequent when the vowel precedes a stop – due to a more gradual formation of constriction (approximation of the articulators) in comparison to the release. In addition, it is noted that the aspirated stops, i. e. English initial voiceless stops, acoustically resemble fricatives, which should be reflected in their segmentation. The main rule for marking a fricative vowel boundary remains the same as in case of the stops, that is a full formant structure. In addition, differences in intensity represented by an intensity curve may also help to identify the boundaries. A fricative followed by a vowel is characterized by an increase in intensity and the boundary should be placed in the middle of the increase.

To summarize, VOT was measured from the release of the stop to the onset of voicing marked by a full formant column – left of the full formant column, at zero crossing. In cases when the voicing onset was too gradual and the full formant columns by themselves did not enable conclusive placement of the boundary, the shape of the waveform was taken into consideration, marking the boundary left of the first regular wave. Finally, in case of multiple releases, the VOT was measured from the first release, as. e. g. in (Millasseau et al. 2019; Nakai and Scobbie 2016).

3.4.2. Marking vowel boundaries

Marking of vowels followed the same principles as described above, which are based on (Machač and Skarnitzl (2009). The primary indicator for marking vowel boundaries on both sides was presence of full formant columns and the boundary was made at zero crossing. In case of transition areas, the boundary was placed in the middle. The formant measurement itself was then conducted in Praat (Boersma and Weenink 2019) automatically, formants were measured in the middle area of the marked vowel. More specifically, 30 % from the ends (marked boundaries) were cut and only the remaining central area was used for formant measurement. Further, the automatically measured values were reviewed with reference to previous formant measurements to reveal potential errors and to correct them manually. Namely, data from the study conducted by Skarnitzl and Volín (2012) were used as a Czech reference point (with the information on female speakers provided privately), whereas data presented in Bjelaković (2017) were used as an English reference point.

3.5. Results

Ideally, the total of 15 VOT (5 /p/, 5 /t/, 5 /k/) tokens per person in each recording was supposed to be collected, that is a total of 600 tokens for bilingual participants – 15 (target words) x 4 (conditions) x 10 (participants). A half represented Czech and the other half represented English tokens of /p, t, k/, leading to 100 tokens for each stop in each language. In addition, the total of 180 tokens of Czech stops were supposed to be collected from a functional monolingual control group, leading to 60 tokens for each Czech stop – 15 (target words) x 1 (condition) x 12 (participants). However, some target words were not produced by the participants or it was not possible to measure VOT of some targets due to e. g. absence of a clear release. Thus, only 756 out of 780 tokens for both groups were used for the analysis.

Analogically, a total of 30 vowel tokens, 5 for each vowel in each recording was presumed to be collected. Following the same calculation method, that is 1200 tokens for bilingual participants (half of that English vowels /ʊ, u, ɒ, ɔ, ʌ, ɑ, half Czech /u, u:, o, o:, a, a:/) and 360 tokens of Czech vowels for monolingual participants. Out of the total of 1560 tokens for both groups, 1463 tokens were analyzed. Reasons for exclusion were similar as in case of VOT, some words were not produced by the participants (misheard, skipped, interpreted differently). In addition, some instances of an English /ɑ/ vowel had to be eliminated since sometimes participants (participants P1, and P7 systematically) opted for /æ/ pronunciation of the /ɑ/ target words, which was allowed for by the experimental context.

3.5.1. Results of VOT analysis

After acquiring absolute VOT values, VOT values relative to the word length were further counted to have a possibility to account for VOT differences due to speech tempo, as discussed in the section Speech rate (word duration).

3.5.1.1. Bilinguals' production in L1 and L2

The first question discussed is whether the bilinguals use their L1 as a basis for production in L2, or whether they created separate categories for L2 voiceless stops. Thus, bilinguals' productions of voiceless stops in a monolingual Czech mode was compared to their production in a monolingual English mode. Repeated Measures ANOVA (for absolute VOT values) showed a significant effect of Language ($F [1,9] = 24.941$, $p = .00074$), of Place ($F [2, 18] = 29.042$, $p = .00000$), and Language-Place Interaction ($F [2, 18] = 10.576$, $p = .00092$). For illustration see the Figure 1 on the following page that shows the interaction of Language and Place. The vertical bars in the Figure 1 indicate a greater variation in bilinguals' production of English stops than of Czech stops.

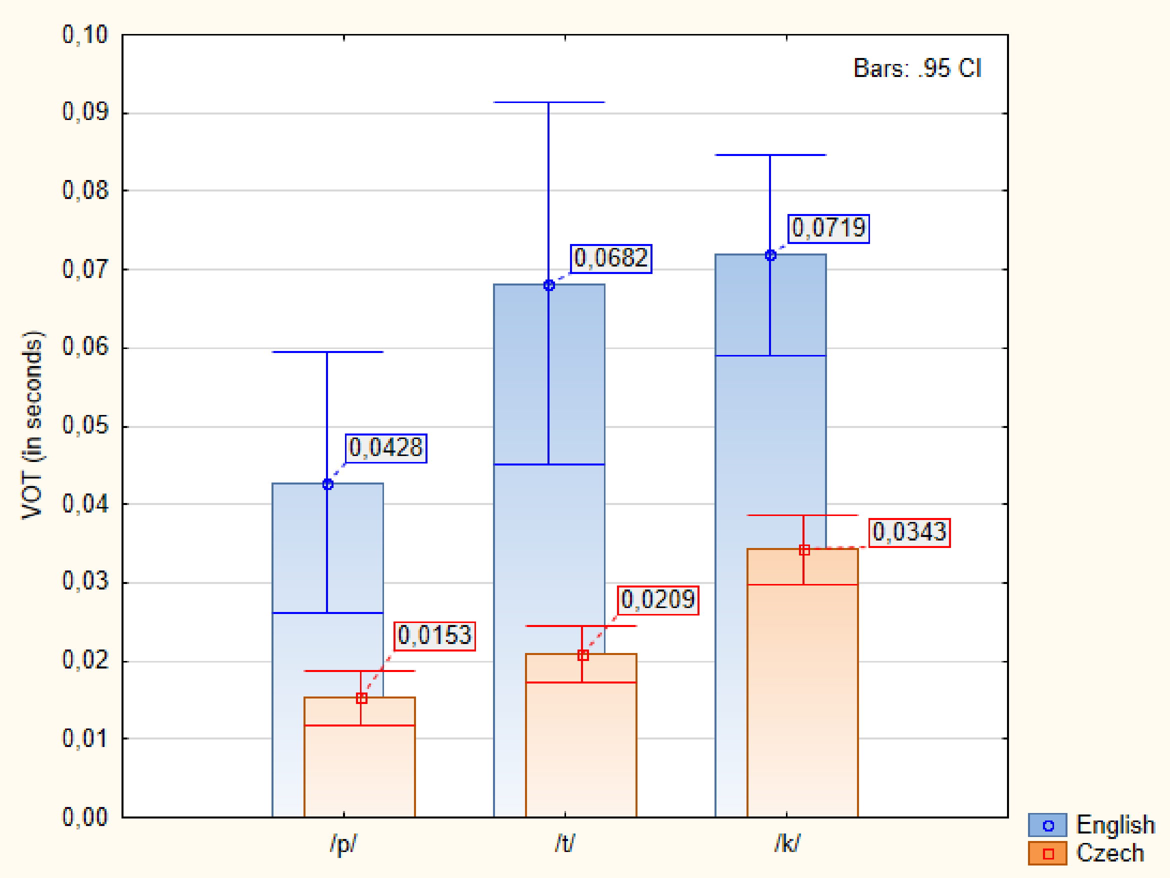

Figure 1: Bilinguals' VOT in Czech and English

The Figure shows absolute VOT of voiceless stops /p, t, k/ produced by bilinguals in Czech (red bars), and in English (blue bars). Voiceless stops are placed on the horizontal axis, vertical axis shows VOT values in seconds.

Repeated Measures ANOVA for values relative to the length of the word confirmed the results, again showing statistical significance for all three discussed effects. The results were following: the effect of Language, (F [1,9] = 36.042, p = .00020), the effect of Place (F [2,18] = 34.281, p = .00000), and the Interaction of Language and Place (F [2,18] = 6.4746, p = .00761).

3.5.1.2. L1 Production: Bilinguals vs. Monolinguals

The second question discussed is whether the bilinguals' L1 stop categories shifted as a result of learning L2. That was investigated by comparing bilinguals' speech production in L1, namely in the Czech monolingual mode, to the functional monolingual group. Repeated Measures ANOVA (for absolute values) showed that the effect of Speaker Group did not reach statistical significance ($F [1,20] = 1.1710$, $p = .29206$). As expected, the effect of Place proved to be statistically significant ($F [2,40] = 142.18$, $p = .00000$). Finally, the Place-Group Interaction did not reach statistical significance ($F [2,40] = 2.4425$, $p = .09981$). For illustration, see a Figure 2 below, representing VOT of Czech /p, t, k/ produced by two different groups of speakers. The figure shows that whereas VOT values of /p/ and /t/ are nearly identical for both groups, /k/ seems to display bigger differences (an average difference about 4 ms).

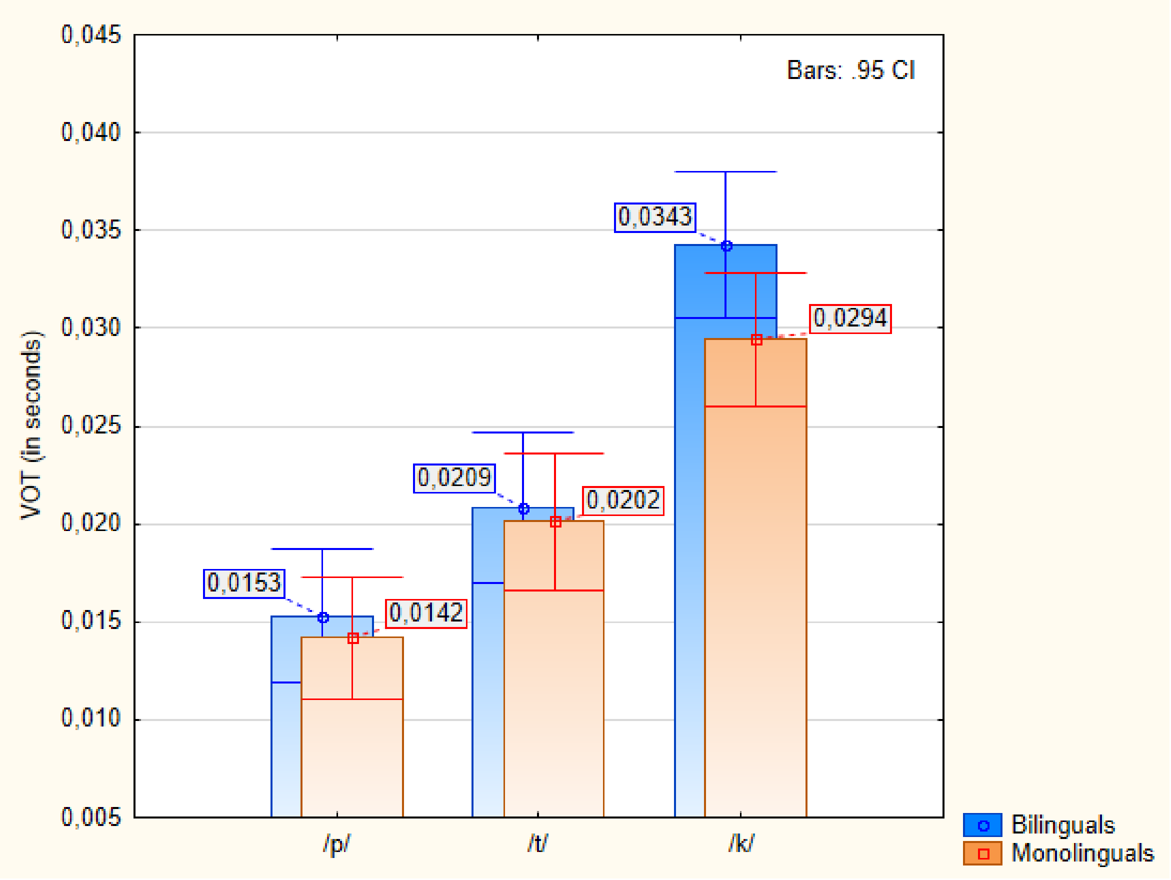

Figure 2: VOT of Czech stops: monolinguals vs. bilinguals

The Figure 2 shows absolute VOT values of Czech /p, t, k/ produced by two groups of speakers: bilingual speakers (blue bars) and monolingual speakers (red bars). The horizontal axis shows individual phonemes /p, t, k/, vertical indicates VOT values in seconds.

Further, the same procedure was repeated with relative measures to see if accounting for word-length differences will reveal statistically significant results between groups. However, Repeated Measures ANOVA revealed quite similar results. The effect of group did not reach statistical significance ($F [1,20] = 1.1436$, $p = .29763$) whereas the effect of Place ($F [2,40] = 153.69$, $p = .00000$) showed to be significant. In addition, Group and Place interaction has just missed statistical significance ($F [2,40] = 3.1863$, $p = .05199$).

3.5.1.3. Dynamic changes in bilinguals' L1 and L2 production

The final question is whether a different activation of languages (Grosjean and Li (2013, 14–18) leads to shifts in language production. Namely, if activation of both L1 and L2 causes a shift of bilinguals' stop categories, stipulating that a default state for comparison is a situation when only the language spoken at the moment is activated. This was investigated by comparing bilingual's production in monolingual and bilingual (more specifically interpreting) conditions. In other words, Czech monolingual condition was compared to the bilingual condition of interpreting from English to Czech, and English monolingual condition was compared to the bilingual condition of interpreting from Czech to English.

Repeated Measures ANOVA were conducted for Czech speech production and English speech production separately (since the difference in production between English and Czech was substantial, a possible production variability due to different modes would most likely disappear). Firstly, English condition comparison (for absolute values) revealed only a statistically significant effect of Place ($F [2,18] = 28.322$, $p = .00000$), but no significant effect of Mode ($F [1,9] = 1.4886$, $p = .25343$), or of the Interaction of Mode and Place ($F [2,18] = .67076$, $p = .52364$). With relative values, we obtained identical results, namely: the effect of Mode ($F [1,9] = .12552$, $p =.73128$), the effect of Place ($F [2,18] = 25.450$, $p = .00001$), and the interaction of Mode and Place ($F [2,18] = 1.9406$, $p = .17251$).

Secondly, Czech conditions were compared, neither absolute, nor relative values comparison showed any statistical significance of Mode. For the absolute values, the effect of Mode ($F [1,9] = 2.9598$, $p = .11947$) did not reach statistical significance, the effect of Place ($F [2,18] = 94.614$, $p = .00000$) was statistically significant, and the interaction thereof was not proved to be significant ($F [2,18] = .53355$, $p = .59551$). As indicated, Repeated Measures ANOVA for relative values did not diverge from already discussed results. For the sake of completeness, the results of ANOVA comparing Czech conditions in relative VOT values are as follows: the effect of Mode ($F [1,9] = 1.8939$, $p = .20204$), of Place ($F [2,18] = 95.438$, $p = .00000$), and the interaction of Mode and Place ($F [2,18] = .37363$, $p = .69345$).

3.5.2. Results of vowel analysis

3.5.2.1. Bilingual's production in L1 and L2

Firstly, the study aimed to find out whether the bilinguals developed new categories for L2 with similar counterparts in Czech. It was hypothesized that Czech short back and central vowels /u, o, a/ will correspond to English lax vowels /ʊ, ɒ, ʌ /, and Czech long vowels /uː, oː, aː/ to English tense vowels /u, ɔ, ɑ/, respectively. For a clearer representation, see the Table 6 with presumed correspondences below.

Czech vowel	**English vowel**
/u/	/ʊ/
/uː/	/u/
/o/	/ɒ/
/oː/	/ɔ/
/a/	/ʌ/
/aː/	/ɑ/

Table 6: Vowel correspondences

The table shows Czech vowels and their presumed equivalent English vowels, that is English vowels that are hypothesized to be perceived as the most similar to the Czech vowels.

Using a vowel normalization tool NORM (Thomas and Kendall 2007), measured formant frequencies were transposed into a Bark scale (via Bark Difference Metric) to minimize participants' physiological differences. NORM (Thomas and Kendall 2007) uses a following formula for conversion of frequency in Hertz into Barks: "Zi = 26.81/(1+1960/Fi) - 0.53", in which Fi signifies a given formant value, borrowed from Traunmüller (1997).

Firstly, bilinguals' production of Czech and English vowels was visually compared. Using NORM (Thomas and Kendall 2007), it was possible to create vowel space of bilinguals as a group (vowel space representations presented in this thesis are always created with the use of this tool). In addition to investigated vowels, two front vowel pairs, English /i, ɪ/ and its Czech counterparts /i, ɪ/ were measured subsequently (one token per person), merely for the purposes of clearer representation of the vowel space.

The bilinguals' vowel space reflecting investigated vowels is presented in the Figure 3 on the following page. The Figure 3 illustrates the degree of overlap of investigated Czech and English equivalent vowels, showing that Czech high back vowels appear to differ the most from their English counterparts. Namely, bilinguals' English lax /ʊ/ seems to be somewhat more open than the Czech short /u/ and both high back English vowels are much more fronted. Unlike high back vowels, Czech mid back vowels partially overlap with their

English counterparts although both Czech /o/ and /o:/ appear to be somewhat more closed than English /ɒ/ and /ɔ/. As regards the remaining vowel pairs, the distances between them seem to be further decreasing. Although overlapping, English lax /ʌ/ is more fronted than Czech short /a/, with English tense /ɑ/ and Czech long /a:/ the situation is reversed. To summarize, the visual representation of bilinguals' vowel production indicates that the greatest differences are in production of high back vowels.

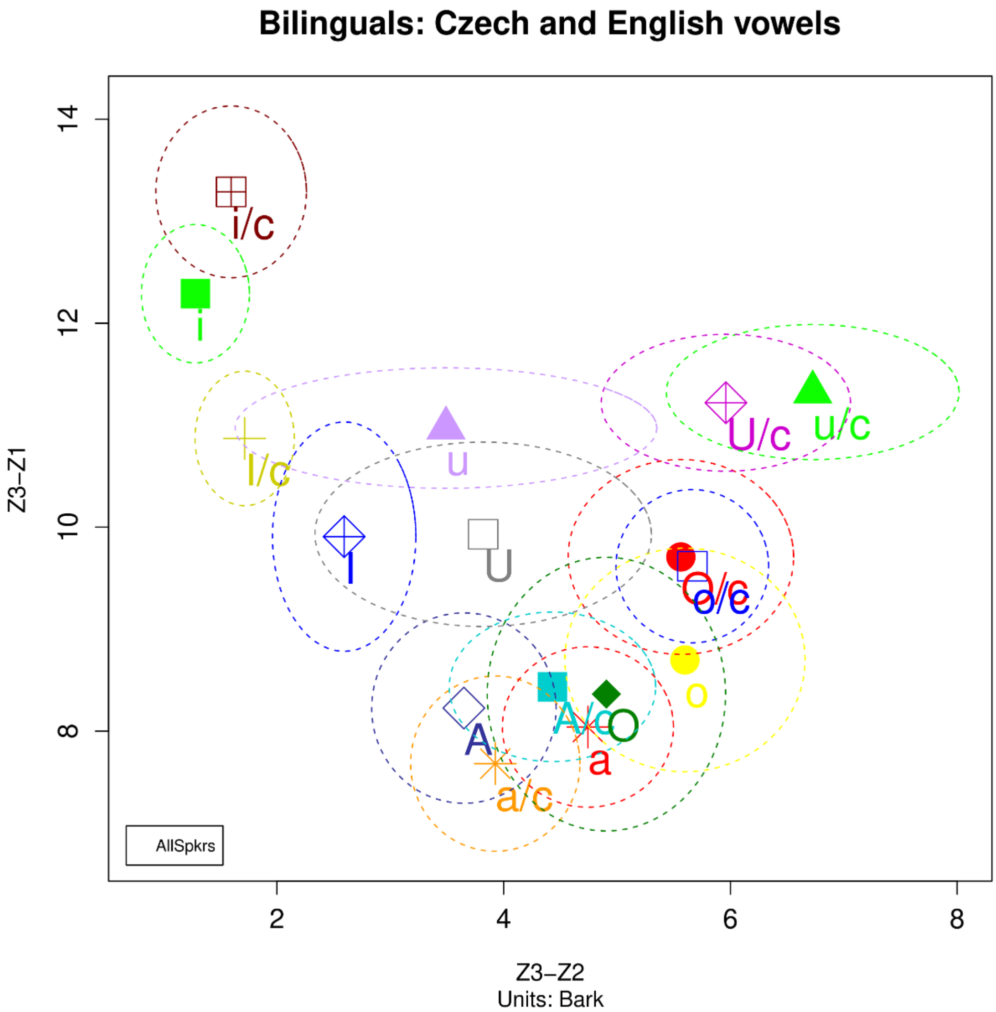

Figure 3: Bilinguals – Czech and English vowels

The figure represents both Czech and English vowels produced by bilinguals. Czech vowels are marked by a symbol "c", capital letters represent either English lax or Czech short vowels, small letters mark either English tense or Czech long vowels. Namely, i, I, u, U, o, O, a, A corresponds to English /i, ɪ, u, ʊ, u, ɔ, ɒ, ɑ, ʌ/ respectively, i/c, I/c, u/c, U/c, o/c, O/c, a/c, A/c marks Czech vowels /i:, ɪ, u:, u, o:, o, a:, a/ respectively. The horizontal axis shows normalized front-back dimension (Z3-Z2), the vertical axis shows normalized height dimension (Z3-Z1), in Bark.

To verify visual observations, Euclidean distances of Czech and English vowel pairs were calculated to confirm between which equivalent vowels there are the greatest distances. Repeated Measures ANOVA revealed the effect of the Vowel Pair to be significant (F [5, 35] = 6. 8535, p = .00015). The Figure 4 shows Euclidean distances, indicating that distances are the greatest for high back vowel pairs. In addition, vertical bars reveal a vast dispersion for these vowel pairs, symbolizing a considerable individual variability among speakers.

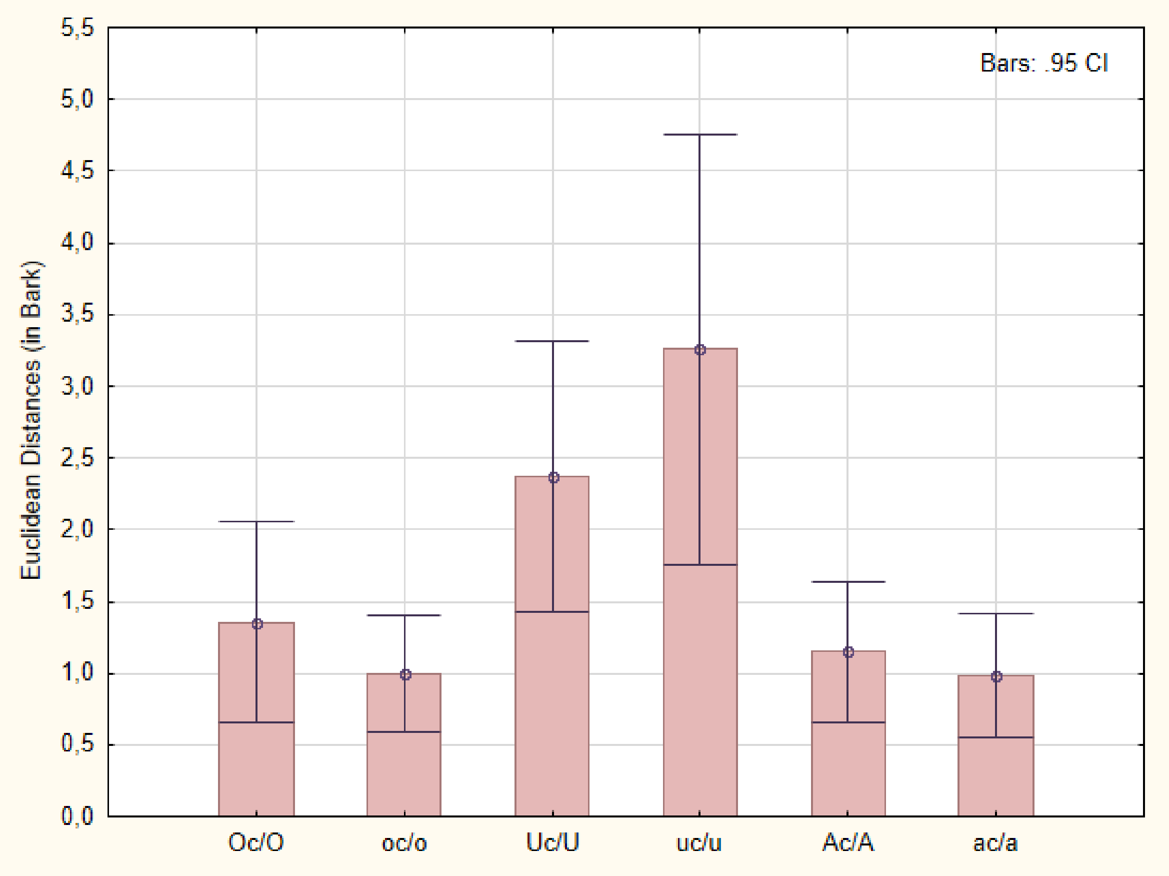

Figure 4: Euclidean Distances (Equivalent Czech and English vowels)

The figure shows Euclidean distances between Czech and English vowels produced by the bilinguals. The individual vowel pairs are placed on the horizontal axis. Czech vowels are marked by a symbol "c", capital letters represent either English lax or Czech short vowels, small letters mark either English tense or Czech long vowels. Namely, u, U, o, O, a, A corresponds to English /u, ʊ, ɔ, ɒ, ɑ, ʌ/ respectively, u/c, U/c, o/c, O/c, a/c, A/c marks Czech vowels /u:, u, o:, o, a:, a/ respectively. Thus, e.g. Oc/O marks the Euclidean distance for short Czech /o/ and English /ɒ/. The vertical axis shows Euclidean distances (in Bark), horizontal axis shows Czech-English vowel pairs.

A post-hoc Tukey HSD test revealed that the differences are significant only for long high back vowel pair Czech /u:/ and English /u/, namely, a mean Euclidean distance for long high back vowel pair (M = 3.26, MSE = 1.01), is significantly different from /o/ – /ɒ/ vowel pair (M = 1.14, MSE = 1.01), /o:/ – /ɔ/ vowel pair (M = 1.00, MSE = 1.01), /a/ – /ʌ/ vowel pair (M = 1.15, MSE = 1.01), and /a:/ – /ɑ/ pair (M = 0.97, MSE = 1.01). The results of the Tukey HSD test are presented in the Table 7 below.

Tukey HSD Test (MSE = 1. 0089; df = 35. 000)						
Vowel Pair	Oc/O 1. 13538	oc/o 0.99550	Uc/U 2.3723	uc/u 3.2585	Ac/A 1.1472	ac/a 0.974484
Oc/O		0.979093	0.347759	0.006990	0.998413	0.974484
oc/o	0.979093		0.092273	0.001035	0.999659	1.000000
Uc/U	0,347759	0,092273		0.500626	0.170797	0.085875
uc/u	0.006990	0.001035	0.500626		0.002301	0.000952
Ac/A	0.998413	0.999659	0.170797	0.002301		0.999434
ac/a	0.974484	1.000000	0.085875	0.000952	0.999434	

Table 7: Tukey HSD Test (Euclidean Distances between Czech and English vowels)

The table presents results of the Tukey HSD Test, showing that among the vowel pairs, only a high back long vowel pair has a significantly greater Euclidean distance. Czech vowels are marked by a symbol "c", capital letters represent either English lax or Czech short vowels, small letters mark either English tense or Czech long vowels. Namely, u, U, o, O, a, A corresponds to English /u, ʊ, ɔ, ɒ, ɑ, ʌ/ respectively, u/c, U/c, o/c, O/c, a/c, A/c marks Czech vowels /u:, u, o:, o, a:, a/ respectively. Thus, e.g. Oc/O marks the Euclidean distance between short Czech /o/ and English /ɒ/.

After seeing the furthest vowel distances, Dependent Sample T-Tests were conducted to see whether the differences between individual vowel pairs are significant. For the following interpretation, it is necessary to keep in mind that the analysis was conducted with normalized values of F1 and F2 in Bark scale. For F1 (in Bark), T-Tests after Bonferroni correction (α = .05/6) revealed statistically significant difference only for Czech short /u/ and English lax /ʊ/ vowel pair, with English /ʊ/ (M = 9.93, SD = 0.72) being more open than Czech /u/ (M = 11.21, SD = 0.56), t (9) = -4.25, p = .002136, as indicated in the Table 8 below.

Variable	Mean (in Bark)	Std. Dv.	N	Diff	Std. Dv. Diff.	t	df	p	Confidence -95. 000%	Confidence +95. 000%
F1 O	8.36330	1.256906								
F1 O/c	9.70810	0.741803	10	-1.34480	1.685156	-2.5236	9	0.032577	-2.55029	-0.13931
F1 o	8.70830	1.047636								
F1 o/c	9.61680	0.578052	10	-0.90850	1.290133	-2.2268	9	0.052969	-1.83141	0.01441
F1 U	9.93010	0.723208								
F1 U/c	11.20820	0.561236	10	-1.27810	0.950535	-4.2520	9	0.002136	-1.95807	-0.59813
F1 u	10.97800	0.448745								
F1 u/c	11.32460	0.564583	10	-0.34660	0.508999	-2.1533	9	0.059712	-0.71072	0.01752
F1 A	8.22560	0.703771								
F1 A/c	8,42130	0.514733	10	-0.19570	0.838330	-0.7382	9	0.479197	-0.79540	0.40400
F1 a	7.93325	0.608033								
F1 a/c	7.87650	0.559696	8	0.05675	0.875408	0.1834	7	0.859715	-0.67511	0.78861

Table 8: Dependent Sample T-Tests (Comparison of F1 of English and Czech vowels)

The table shows results of Dependent Sample T-Tests which illustrate statistically significant differences in F1 of Czech short /u/ and English tense /ʊ/. Czech vowels are marked by a symbol "c", capital letters represent either English lax or Czech short vowels, small letters mark either English tense or Czech long vowels. Namely, u, U, o, O, a, A corresponds to English /u, ʊ, ɔ, ɒ, ɑ, ʌ/ respectively, u/c, U/c, o/c, O/c, a/c, A/c marks Czech vowels /u:, u, o:, o, a:, a/ respectively. The mean values are in Bark.

On the other hand, T-Tests for F2 (in Bark) after Bonferroni correction (α = .05/6) revealed statistically significant differences for both high back vowel pairs and for Czech short /a/ and English lax /ʌ/ vowels, with English vowels being more fronted than their Czech counterparts. Namely, F2 of English /ʊ/ in Bark (M = 3.82, SD = 1.21) was lower than that of Czech /u/ (M = 5.96, SD = 0.91), t (9) = -5.08, p = .000664. The same applied for English /u/ (M = 3.52, SD = 1.38) and Czech /u:/ (M = 6.74, SD = 1.04), t (9) = -6.44, p = .000119. Identical tendency was observed even in case of English /ʌ/ (M = 3.65, SD = 0.58) and Czech /a/ vowel pair (M = 4.41, SD = 0.56), t (9) = -4.20, p = .002291. The results of T-Tests for F2 are presented in the Table 9.

Variable	Mean (in Bark)	Std. Dv.	N	Diff	Std. Dv. Diff	t	df	p	Confidence -95. 000%	Confidence +95. 000%
F2 O	4.906000	0.792282								
F2 O/c	5.562600	0.611626	10	-0.65660	0.843607	-2.4613	9	0.036083	-1.26008	-0.05312
F2 o	5.596900	0.895374								
F2 o/c	5.663800	0.417635	10	-0.06690	0.912681	-0.2318	9	0.821881	-0.71979	0.58599
F2 U	3.819000	1.214240								
F2 U/c	5.964100	0.905597	10	-2.14510	1.335626	-5.0788	9	0.000664	-3.10055	-1.18965
F2 u	3.517800	1.377836								
F2 u/c	6.744700	1.038827	10	-3.22690	1.583964	-6.4423	9	0.000119	-4.36000	-2.09380
F2_A	3.648700	0.581458								
F2 A/c	4.413100	0.555861	10	-0.76440	0.574900	-4.2046	9	0.002291	-1.17566	-0.35314
F2 a	4.648250	0.524590								
F2 a/c	4.112625	0.333833	8	0.53563	0.515331	2.9398	7	0.021719	0.10480	0.96645

Table 9: Dependent Sample T-Tests (Comparison of F2 of English and Czech vowels)

The table shows results of Dependent Sample T-Tests which illustrate statistically significant differences in F2 of high back vowels and English lax /ʌ/ and Czech short /a/ vowel. Czech vowels are marked by a symbol "c", capital letters represent either English lax or Czech short vowels, small letters mark either English tense or Czech long vowels. Namely, u, U, o, O, a, A corresponds to English /u, ʊ, ɔ, ɒ, ɑ, ʌ/ respectively, u/c, U/c, o/c, O/c, a/c, A/c marks Czech vowels /u:, u, o:, o, a:, a/ respectively. The mean values are in Bark.

To summarize, it appears the bilinguals have established distinct categories for English /u/, /ʊ/, and /ʌ/. However, as the results of Repeated Measures ANOVA suggest, even though the bilinguals as a group seemed to establish distinct categories for high back vowels, there were vast differences in production of these vowel pairs among participants. For example, one participant (P4) showed an extreme degree of fronting for English high back vowels, as illustrated by the Figure 5 on the following page. Although in line with a more front quality of both English /u/ and /ʊ/ in comparison to Czech /u:/ and /u/ (Bjelaković 2017; Skarnitzl and Volín 2012), the fronting may be even more extreme than for native English speakers. On the other hand, if we look at this participant's production of Czech mid back vowels, not only that these are produced with the same quality, which may be expected for Czech speakers (Skarnitzl and Volín 2012), but the quality of English equivalent vowels is rather unchanged, meaning that this participant, not diverging from the whole group, seems to use her Czech mid back vowel category for production of English /ɒ/ and /ɔ/. If anything, the English /ɒ/ may be somewhat more fronted and lowered in comparison to

Czech /o/, although lowering may be anticipated, fronting is not something that would be expected for English production of this vowel (Bjelaković 2017; Skarnitzl and Volín 2012). The use of L1 as a source for L2 production seems to apply even to her /ʌ/ vowel, which is produced identically as Czech /a/. As regards the final vowel pair, the participant's Czech /a:/ seems to overlap with the English /ɑ/, although it may be said that in accordance with English it is somewhat further back and raised (Bjelaković 2017, Skarnitzl and Volín 2012).

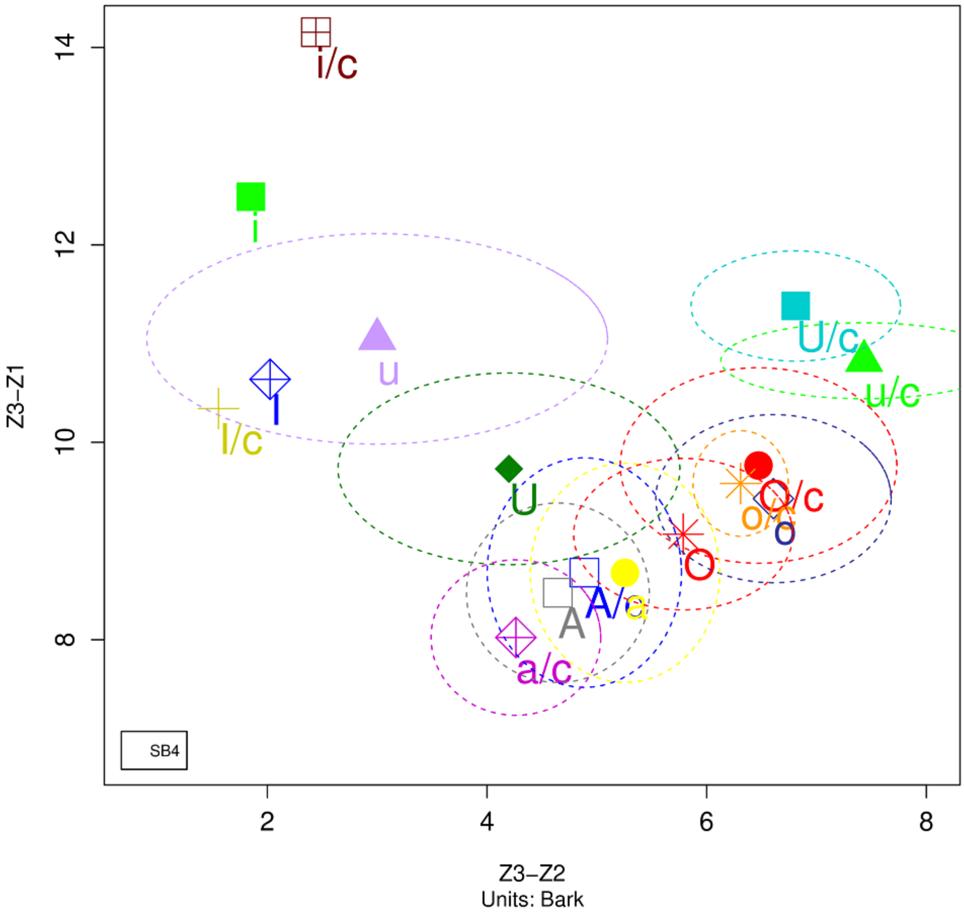

Figure 5: P4 – Czech and English vowels

The figure represents both Czech and English vowels produced by a bilingual participant (P4) who produced her English high back vowels in an extremely fronted manner. Czech vowels are marked by a symbol "c", capital letters represent either English lax or Czech short vowels, small letters mark either English tense or Czech long vowels. Namely, i, I, u, U, o, O, a, A corresponds to English /i, ɪ, u, ʊ, ɔ, ɒ, ɑ, ʌ/ respectively, i/c, I/c, u/c, U/c, o/c, O/c, a/c, A/c marks Czech vowels /i:, ɪ, u:, u, o:, o, a:, a/ respectively. The horizontal axis shows normalized front-back dimension (Z3-Z2), the vertical axis shows normalized height dimension (Z3-Z1), in Bark.

On the other hand, as seen in the Figure 6 on the following page , another participant (P6) produced English high back vowels in the same manner as in Czech, opposite to the trend observed for the whole group. The Figure 6 further shows that the participant seems to attribute the same central quality of central low Czech vowels to their production of English vowels /ʌ/ and /ɑ/, however, she might have noticed some differences in height, producing both English vowels in a more closed manner than her Czech vowels, in accordance with a somewhat lower quality of both Czech vowels /a/ and /a:/ in comparison to English /ʌ/ and /ɑ/ as reported in Bjelaković (2017) and Skarnitzl and Volín (2012). Finally, although for this speaker Czech mid back vowels /o/ and /o:/ are quite close to their English counterparts, suggesting Czech vowels might be used as the basis for production of equivalent L2 vowels, both English /ɒ/ and /ɔ/ seem to be somewhat higher. According to reference data on these vowels in (Bjelaković (2017) and Skarnitzl and Volín (2012), it is possible for English /ɔ/ to be slightly higher and further in back than Czech /o:/ but having English /ɒ/, which is characterized as a low vowel, higher than a Czech /o/, is rather unusual. It might be hypothesized that the speaker does not differentiate between these two English vowels (/ɒ/ and /ɔ/), since in Czech there is not a difference in the quality for /o/ and /o:/ (Skarnitzl and Volín (2012).

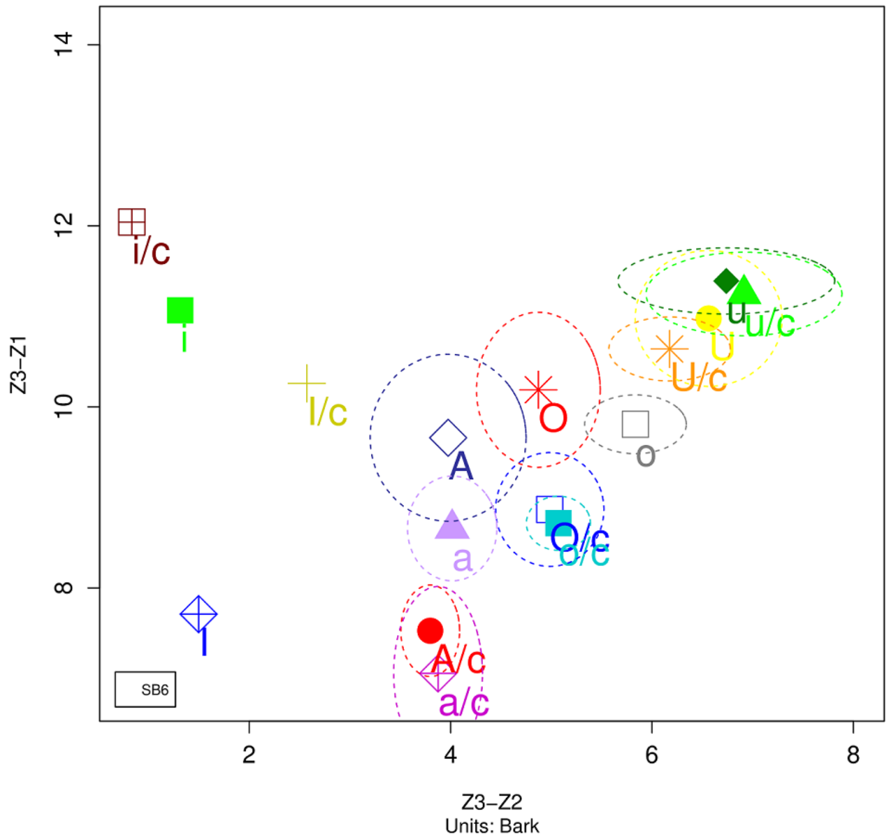

Figure 6: P6 – Czech and English vowels

The figure represents both Czech and English vowels produced by a bilingual participant (P6) who produced her English high back vowels in a Czech-like manner. Czech vowels are marked by a symbol "c", capital letters represent either English lax or Czech short vowels, small letters mark either English tense or Czech long vowels. Namely, i, I, u, U, o, O, a, A corresponds to English /i, ɪ, u, ʊ, ɔ, ɒ, ɑ, ʌ/ respectively, i/c, I/c, u/c, U/c, o/c, O/c, a/c, A/c marks Czech vowels /i:, ɪ, u:, u, o:, o, a:, a/ respectively. The horizontal axis shows normalized front-back dimension (Z3-Z2), the vertical axis shows normalized height dimension (Z3-Z1), in Bark.

3.5.2.2. L1 Production: Bilinguals vs. Monolinguals

The second question was whether bilinguals' categories for Czech vowels shifted as a result of L2 acquisition. Therefore, bilinguals' production of Czech back and central vowels /u, u:, o, o:, a, a:/ was compared to the production of a group of functional monolinguals. The procedure followed the first question: using NORM (Thomas and Kendall 2007) to minimize physiological differences, a vowel space incorporating Czech vowels produced by these two groups of speakers was created. The vowel space is presented in the Figure 7 below.

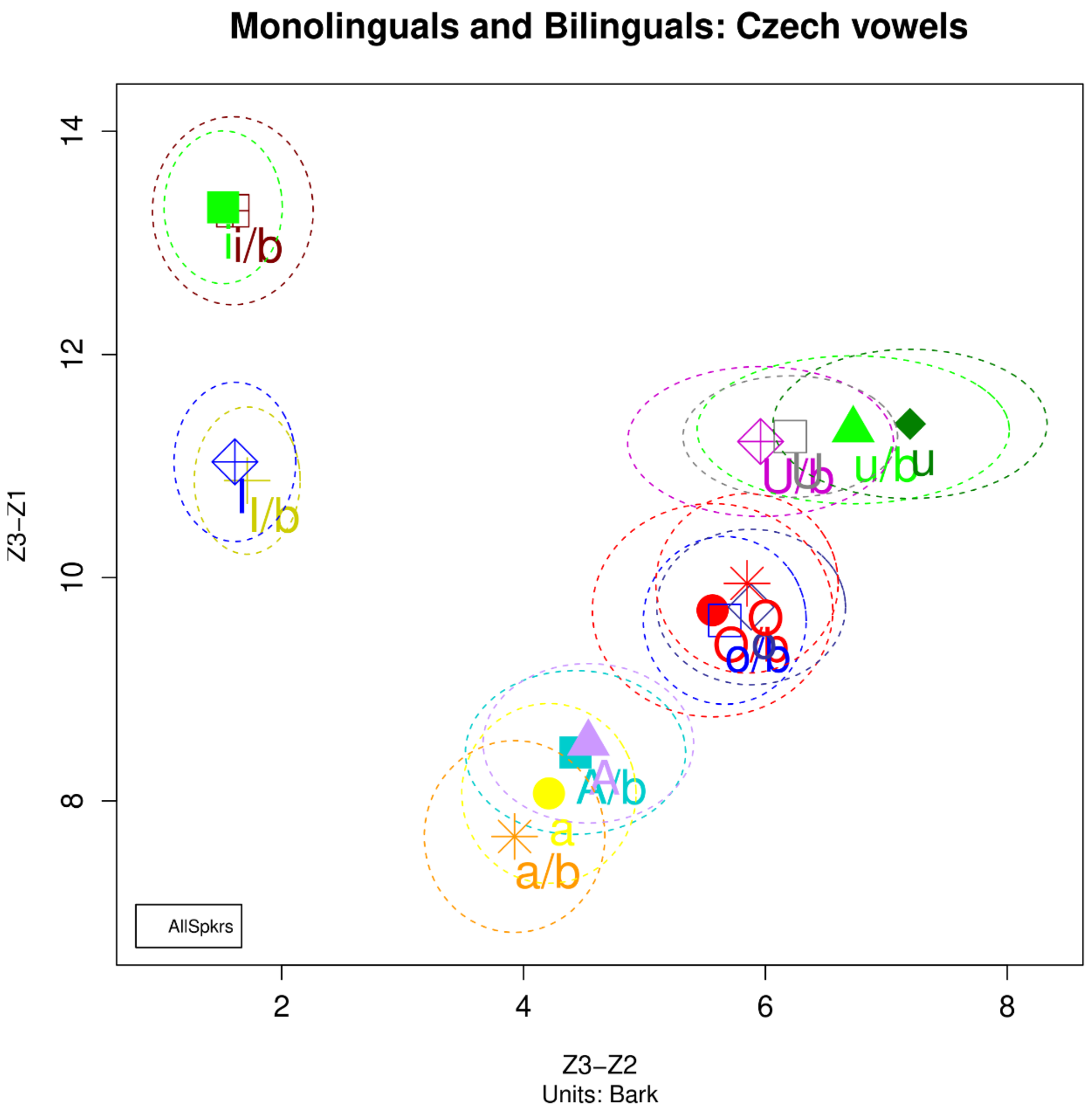

Figure 7: Monolinguals and Bilinguals: Czech vowels

The figure shows Czech vowels produced by two groups of speakers: functional monolinguals and bilinguals. A symbol "b" marks vowels produced by bilinguals. Capital letters refer to Czech short vowels whereas small letters refer to Czech long vowels. Namely, i, I, u, U, o, O, a, A corresponds to monolingual Czech /i:, ɪ, u:, u, o:, o, a:, a/, whereas i/b, I/b, u/b, U/b, o/b, O/b, a(b, A/b corresponds to bilingual Czech /i:, ɪ, u:, u, o:, o, a:, a/, respectively. The horizontal axis shows normalized front-back dimension (Z3-Z2), the vertical axis shows normalized height dimension (Z3-Z1), in Bark.

As it can be seen in the figure above, all vowels are to some extent overlapping, however, it may be hypothesized that if there are any significant distinctions, they are between high back vowels which appear to be somewhat more fronted for the bilingual group. Further, the bilingual long central /a:/ appears to be somewhat lower.

As the next step, Euclidean distances between bilinguals' Czech vowels and monolingual group mean values were calculated to see whether some of the bilingual's vowels diverged from the monolingual average more substantially. Repeated Measures ANOVA did not reveal any significant effect of Vowel Pair ($F [5, 45] = .68493$, $p = .63727$). However, the Figure 8 illustrates a great variability for low central /a:/ and high back vowels, especially /u:/, suggesting the differences may be significant at least for some of the participants.

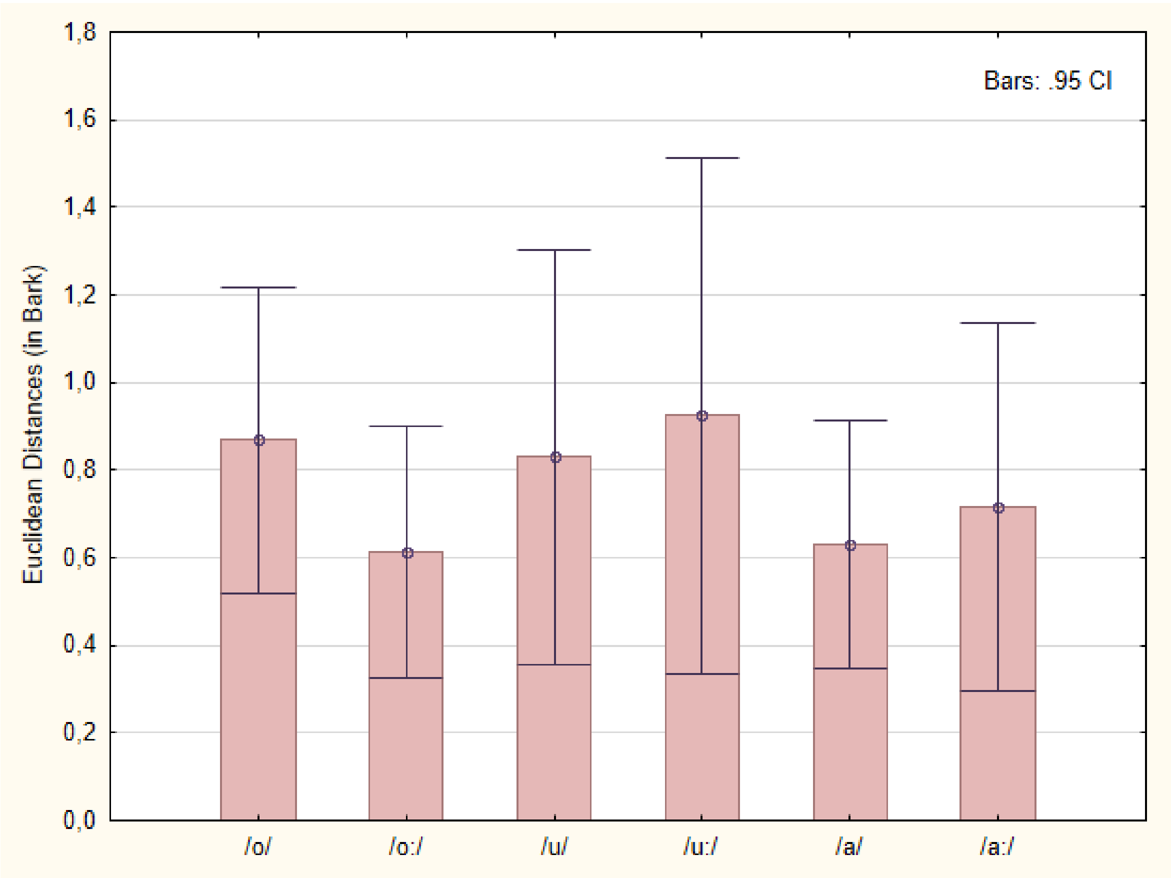

Figure 8: Euclidean distances (Czech vowels produced by Monolinguals vs. Bilinguals)

The Figure shows Euclidean distances between monolingual average of Czech vowels and Czech vowels of individual bilinguals. The horizontal axis shows individual Czech vowels, the vertical axis shows Euclidean distances (in Bark).

Further, Independent T-Tests by group did not reveal any significant differences (See Table 18 in the Appendix) in production by group for any of the Czech vowels, in line with the findings of ANOVA. Therefore, Single Sample T-Tests were further conducted for the vowels which manifested the greatest degree of variation, namely for high back vowels and long low central vowel /a/, with monolingual group mean values of given vowels as a reference point. Significant results of Single Sample T-Tests are summarized in the Table 10 below.

Participant	Mean (in Bark)	Std. Dv.	N	Std. Err.	Reference constant	t-value	df	p
/a:/ vowel – F1								
P1	6.891600	0.407928	5	0.182431	8.067000	-6.44298	4	0.002986
P7	6.910600	0.747332	5	0.334217	8.067000	-3.46003	4	0.025817
/a:/ vowel – F2								
P7	3.045600	0.190035	5	0.084986	4.210000	-13.7010	4	0.000164
/u/ vowel – F1								
P2	10.26760	0.457776	5	0.204724	11.26400	-4.86705	4	0.008237
P7	12.06020	0.431368	5	0.192914	11.26400	4.12723	4	0.014527
/u/ vowel – F2								
P1	5.256400	0.696433	5	0.311454	6.206000	-3.0489	4	0.038068
P2	3.952000	0.418263	5	0.187053	6.206000	-12.0501	4	0.000272
P10	6.830800	0.312013	5	0.139537	6.206000	4.4777	4	0.011009
/u:/ vowel – F1								
P3	11.74025	0.223980	4	0.111990	11.37800	3.23467	3	0.048045
P5	12.30860	0.314725	5	0.140749	11.37800	6.61176	4	0.002713
P7	12.12020	0.376173	5	0.168230	11.37800	4.41182	4	0.011584
P8	11.11900	0.188931	5	0.084493	11.37800	-3.06536	4	0.037462
P9	10.66180	0.311927	5	0.139498	11.37800	-5.13413	4	0.006819
P10	10.81020	0.416040	5	0.186059	11.37800	-3.05173	4	0.037964
/u:/ vowel – F2								
P1	6.220200	0.634318	5	0.283675	7.196000	-3.4398	4	0.026297
P2	4.088600	0.515689	5	0.230623	7.196000	-13.4739	4	0.000176
P9	6.436400	0.585821	5	0.261987	7.196000	-2.8994	4	0.044145

Table 10: Single Sample T-Tests (selected vowels)

The table shows significant results of Single Sample T-Tests of F1 and F2 of selected Czech vowels /a:/, /u/, and /u:/ of individual bilinguals. F1 and F2 values are presented in Bark scale.

In the following analysis, it needs to be taken into consideration that reported mean values are in a normalized Bark scale. Participant P1 produced her Czech /u:/ (M = 6.22, SD = 0.63) with a significantly lower F2 mean (in Bark) than the mean for a functional monolingual reference group, t (4) = -3.44, p = .026297. Considering the speaker fronted their English /u/ (F2: 2.806 Barks), it may be argued that this divergence from the monolingual norm is due to influence of English and that the speaker is experiencing assimilatory effects, moving their L1 production of Czech long /u:/ to resemble a similar category of English /u/. The same applies for F2 of participant's short /u/ (M = 5.26, SD = 0.70), which also differed significantly from the monolingual reference, t (4) = -3.05, p = .038068, with a more fronted quality, resembling participant's English /ʊ/ (F2: 3.922 Barks). This participant further decreased F1 (in Bark) of her /a:/ (M = 6.89, SD = 0.41) in comparison to the monolingual reference, t (4) = -6.44, p = .002986, a possible influence of English as well, e. g. as a way creating further distinctions between a somewhat more closed English /ɑ/ based on comparison of data in (Bjelaković (2017) and Skarnitzl and Volín (2012), however, since the data on English vowel /ɑ/ for this participant is missing, it cannot be determined if this was the motivation behind lowering of Czech /a:/.

Similarly to P1, Participant 2 produced her long Czech /u:/ (M = 4.09, SD = 0.52) with a significantly lower F2 (in Bark) than the monolingual group, t (4) = -13.47, p = .000176. This fronting thus indicates the same assimilatory effects, given that the participant produced their English tense /u:/ in a more fronted manner (F2: 2.309 Barks). The same influence of L2 was apparent in case of F2 of her short Czech /u/ (M = 3.95, SD = 0.42), that significantly differed from the monolinguals' mean production, t (4) = -12.05, p = .000272. F1 (in Bark) of her short Czech /u/ (M = 10.27, SD = 0.46) was distinctly lower than the monolingual group's mean as well, t (4) = -4.87, p = .008237, signifying lowering of her short Czech /u/. When comparing F1 for short Czech /u/ and English /ʊ/ based on means reported in Bjelaković (2017) and Skarnitzl and Volín (2012), the height does not seem to differ too conspicuously, although /ʊ/ is somewhat more open. In addition, the participant seemed to produce somewhat lower /ʊ/ (F1 = 9.820 Barks) so this change may be motivated by assimilation to their English values as well.

Significant differences from monolinguals, t (3) = 3.23, p = .048045, were observed even for F1 of Czech long /u:/ produced by a Participant 3 whose /u:/ was consequently more closed (M = 11.74, SD = 0.22). Based on Bjelaković (2017) and Skarnitzl and Volín (2012), average F1 values for female speakers for Czech long /u:/ and English tense /u/ seem to be almost identical, and so were this bilingual's values since her English /u/ average for F1 was 11.742 Barks, thus this distinction does not seem to be caused by her L2. Nevertheless, Participant 5 (MS = 12.31, SD = 0.31), showed a same tendency of increasing F1 (in Barks) in comparison to monolinguals, t (4) = 6.61, p= .002713, but unlike in case of Participant 3, here, the change in production may be motivated by a lower height of their English /u/ (F1: 10.920 Barks), raising her Czech /u:/, possibly in an attempt to enhance the contrast between her English and Czech categories. The same reasoning seems to apply even in case of Participant 7 who also raised their Czech /u:/ (M = 12.12, SD = 0.38), in comparison to the control group, t (4) = 4.41, p = .011584, and also produced a somewhat lower English /u/ (F1:11.483 Barks). This participant further produced more closed Czech short /u/ (M = 12.06, SD = 0.43), than monolinguals t (4) = 4.13, p = .014527, possibly due to same motivation of preserving contrasts (F1 of English /ʊ/: 8.757 Barks). Finally, P7 differed in her production of both F1 and F2 of Czech long /a:/ vowel. For P7, the F1 of /a:/ (M= 6.91, SD = 0.33), was more open than the monolingual average, t (4) = -3.46, p = .025817. In case of F2 of /a:/ (M = 3.05, SD = 0.19), the bilingual's mean was significantly lower than that of monolinguals', t (4) = -13.70, p = .000164, indicating fronting of the vowel. The motivation behind these changes may be again to diverge as much as possible from the English back /ɑ/ (Bjelaković (2017), however, unfortunately, there are no tokens of /ɑ/ vowel for this speaker to verify this hypothesis.

As several other participants, Participant 8 produced long Czech /u:/ with a significantly lower F1 (M = 11.12, SD = 0.19) from the monolingual average for this vowel, t (4) = -3.07, p = .037462, however, since as discussed above, English and Czech do not seem to differ in F1 value of this vowel, and neither does the participant's English /u/ (F1: 11.021 Barks), it is not clear what motivates the difference. The situation was identical for Participants 9 (M= 10.66, SD = 0.31), t (4) = -5.13, p = .006819 and P10 (M = 10.81, SD = 0.42), t (4) = -3.05, p = .037964, with also unclear motivation of the deviation from monolingual group, due to their very similar values for both long /u:/ and English tense /u/. Further, Participant 9 fronted their /u:/ vowel (M = 6.44, SD = 0.59) when compared to monolingual's mean F2 for /u:/, t (4) = -2.90, p = .044145, possibly as a result of assimilating Czech /u/ to her English, more fronted tense /u/ (F2: 4.074 Barks). Finally, Participant 10 produced Czech short /u/ in a more back manner (M = 6.83, SD = 0.31) than monolingual control group, t (4) = 4.48, p = .011009). Given that the participant produces a corresponding high back vowel /ʊ/ in a fronted manner (F2 average: 4.165, it may be hypothesized that participant's production of Czech /u/ is motivated by clear separation of categories, resulting in a diverging effect. In addition, participant P10 also produces Czech long /u:/ with a lower F1 (M = 10.81, SD = 0.42) than the average reported for monolinguals, t (4) = -3.05, p = .037964, with unclear reasoning (F1 of English /u/: 10.710 Barks).

3.5.2.3. Dynamic changes in bilinguals' L1 and L2 production

The third goal was to discover whether bilinguals' production shifts in response to a different degree of activation of languages. To find out, bilinguals' production in a monolingual mode, where only the language produced is activated, was compared to interpreting, which is a bilingual mode characterized by the same activation of both languages involved (Grosjean and Li 2013, 14–18)

3.5.2.3.1. Czech production

As in for the previous analyses, Euclidean distances of bilinguals' vowels were calculated, namely distances between the same Czech vowels produced in two different conditions: Czech monolingual condition and interpreting into Czech condition. Repeated Measures ANOVA did not reveal any of the distances to be significantly different ($F [5, 45] = .94581$, $p = .46092$). However, due to high dispersion for several vowel pairs it may be expected that at least for some speakers there were production differences in these two different conditions, as illustrated by the Figure 9.

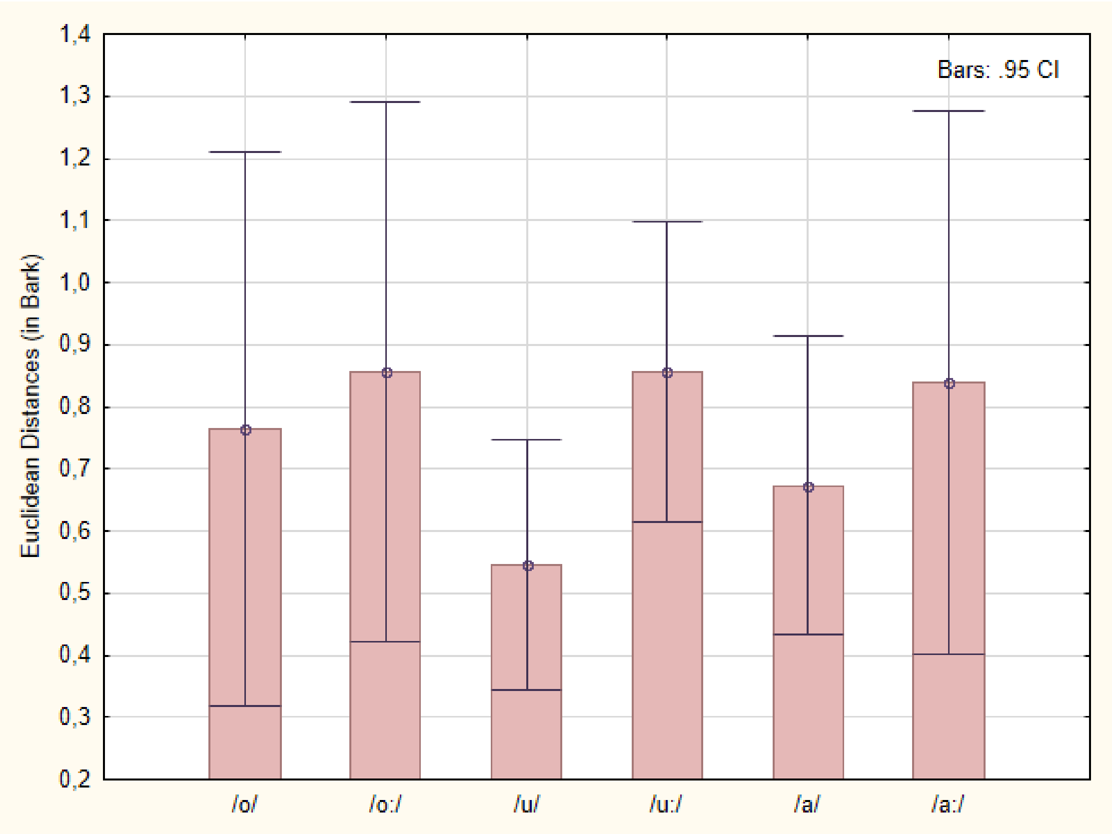

Figure 9: Euclidean distances (Czech vowels in two different conditions)

The figure shows Euclidean distances of Czech vowels produced by bilinguals in two different conditions: a bilingual interpreting condition and a monolingual repetition condition. The horizontal axis shows individual Czech vowels, the vertical axis represents the Euclidean distances (in Bark).

Dependent Sample T-Tests for F1 and F2 (after Bonferroni correction (α = .05/6) did not reveal any of the differences to be significant, both can be seen in the Appendix, in tables Table 19, and Table 20. However, the high dispersion suggests that although no general tendency seems to appear for the group, some speakers may have changed production of some vowels in interpreting. For example, participant P5 shifted her long /u:/ vowel further back in the interpreting condition, as illustrated in the Figure 10.

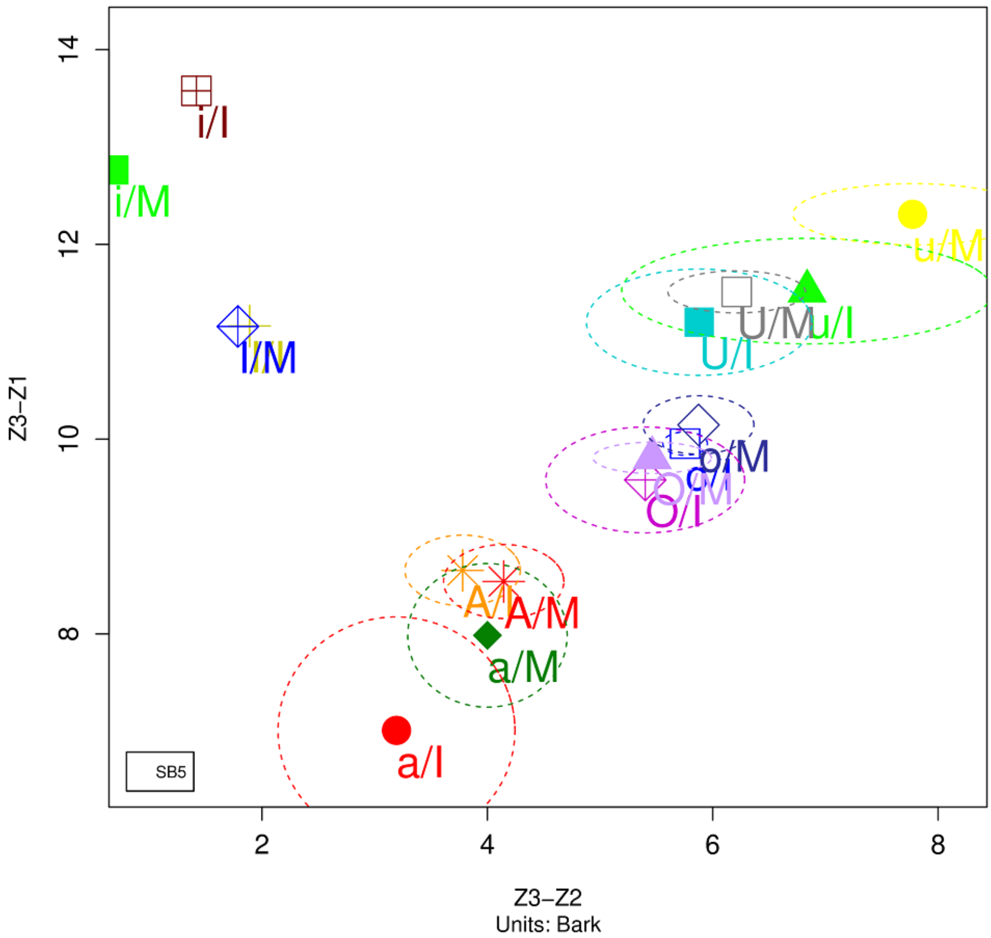

Figure 10: Czech production in two conditions (P5)

The figure shows Czech vowels produced by a participant P5 in two different conditions: bilingual interpreting and monolingual repetition condition. A symbol "M" marks a monolingual repetition mode, a symbol "I" marks a bilingual interpreting mode. Capital letters mark Czech short vowels, small letters mark Czech long vowels. Namely, i, I, u, U, o, O, a, A marks Czech vowels /i:, ɪ, u:, u, o:, o, a:, a/ respectively. Thus, for example o/I refers to Czech long /o:/ produced in an interpreting condition. The horizontal axis shows normalized front-back dimension (Z3-Z2), the vertical axis shows normalized height dimension (Z3-Z1), in Bark.

Both participants' high back vowels shift in the monolingual Czech mode, moving further back, long /u:/ vowel more noticeably. A possible explanation is that the participant is motivated by keeping the Czech and English categories separate and diverges further from her English categories. Since the participant produced her English high back vowels with more fronting (F2 of /ʊ/: 1787.9 Hz; F2 of /u/: 1972.2 Hz) than in Czech (F2 of /u/:1105.0

Hz; F2 of /u:/: 974.8 Hz), reflecting the differences between Czech and English, this explanation may be plausible (Bjelaković 2017; Skarnitzl and Volín 2012). Further, the participant considerably fronts and lowers long Czech /a:/ in the interpreting condition as well, which again can be explained by divergence from their English category, as the participant produces her English /ɑ/ further in the back (F2: 1296.6 Hz) than their Czech /a:/ (F2: 1523.4), in accordance with the more back and somewhat more closed pronunciation of English /ɑ/ (Bjelaković 2017; Skarnitzl and Volín 2012). However, not all vowels seem to shift, the production of mid back Czech vowels and short Czech /a/ seems rather unaltered. This was the case for all vowels of some speakers, e.g. for P3 as seen in the Figure 11.

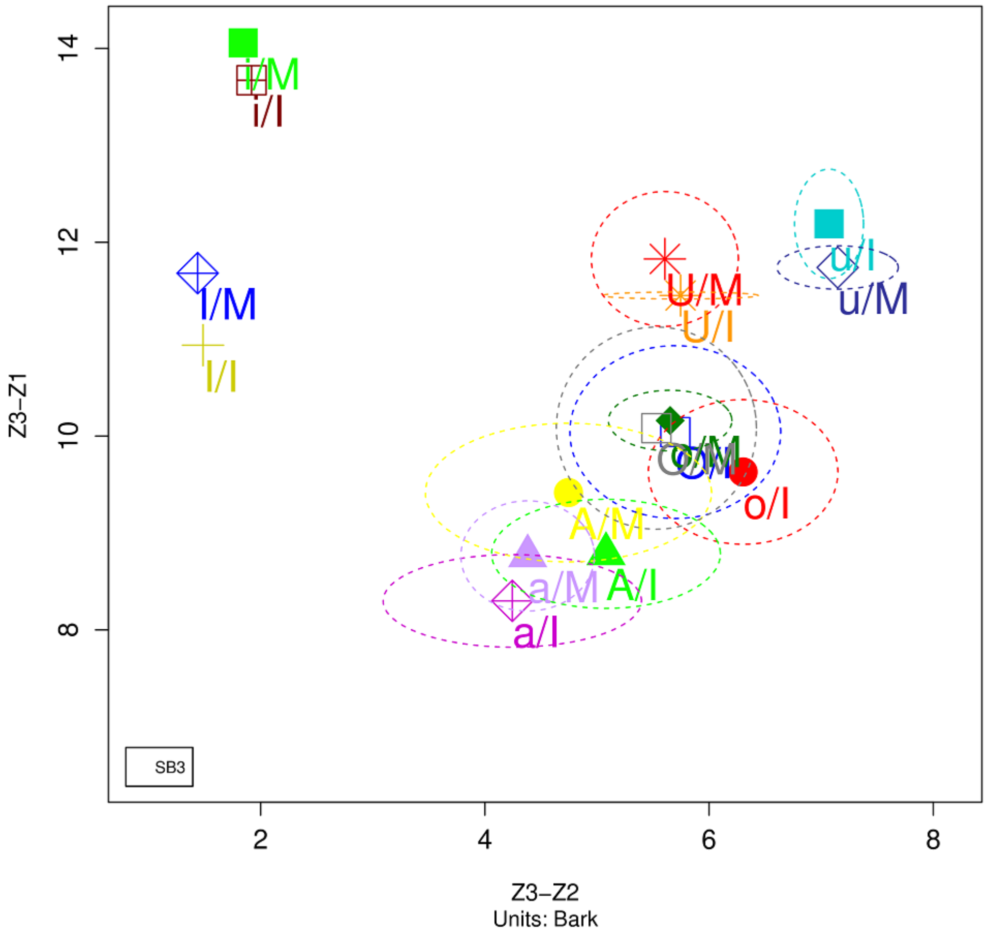

Figure 11: Czech production in two conditions (P3)

The figure shows Czech vowels produced by a participant P3 in two different conditions: bilingual interpreting and monolingual repetition condition. A symbol “M” marks a monolingual repetition mode, a symbol “I” marks bilingual interpreting mode. Capital letters marks letters Czech short vowels, small letters mark Czech long vowels. Namely, i, I, u, U, o, O, a, A marks Czech vowels /i:, ɪ, u:, u, o:, o, a:, a/ respectively. Thus, for example o/I refers to Czech long /o:/ produced in an interpreting condition. The horizontal axis shows normalized front-back dimension (Z3-Z2), the vertical axis shows normalized height dimension (Z3-Z1), in Bark.

3.5.2.3.2. English production

The same procedure was followed when comparing production in English monolingual repetition condition and English bilingual interpreting condition. After calculating Euclidean distances between English vowels in these two conditions, Repeated Measures ANOVA was conducted which revealed that even in case of English vowels, no vowel pairs distance differed more from the other ($F [5,35] = .77888$, $p = .57166$). High dispersion in the distances, as already seen in the comparison between Czech condition for most vowels again indicated individual differences. Conducting Dependent Sample T-Tests for both F1 and F2 (in Bark scale, after Bonferroni correction [$\alpha = .05/6$]) did not show any significant differences in production of any of the vowels, as illustrated in the Appendix, in the Table 21, and Table 22. Looking at the individual data, e. g. participant P10 seems to have rather stable categories and most vowels did not shift considerably, as illustrated in the Figure 12 below.

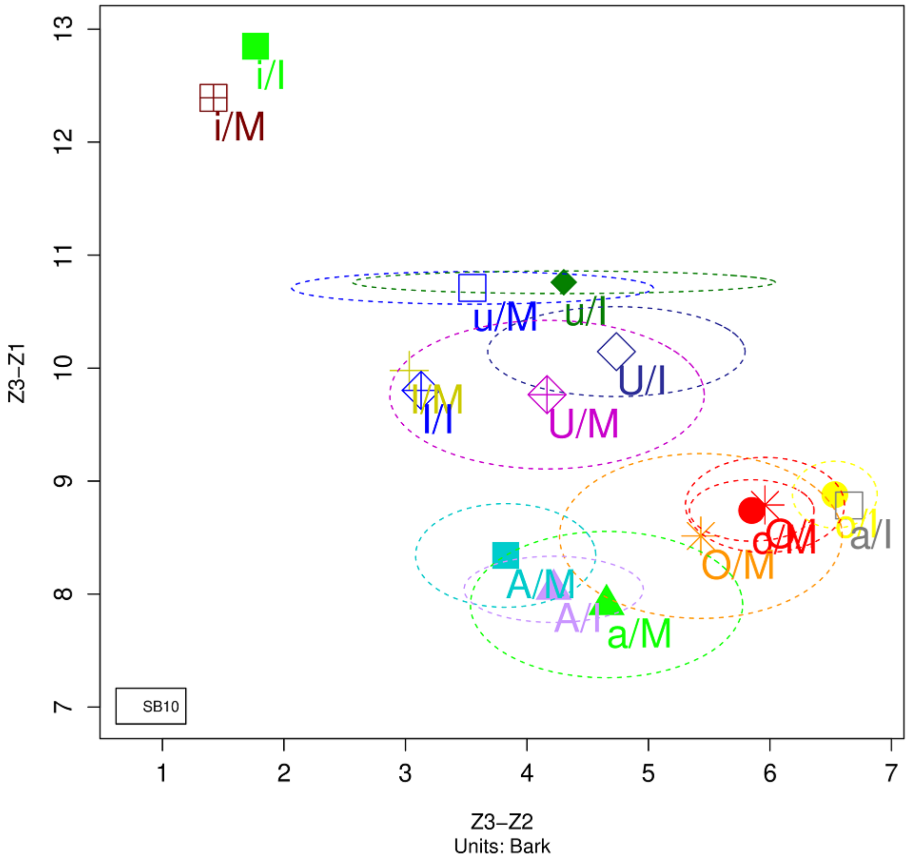

Figure 12: English production in two conditions (P10)

The figure shows English vowels produced by a participant P10 in two different conditions: bilingual interpreting and monolingual repetition condition. A symbol "M" marks a monolingual repetition mode, a symbol "I" marks bilingual interpreting mode. Capital letters marks letters English lax vowels, small letters mark English tense vowels. Namely, i, I, u, U, o, O, a, A marks English vowels /i:, ɪ, u, ɔ, ɒ, ɑ, ʌ/ respectively. Thus, for example U/I refers to English lax /ʊ/ produced in an interpreting condition. The horizontal axis shows normalized front-back dimension (Z3-Z2), the vertical axis shows normalized height dimension (Z3-Z1), in Bark.

Namely, the participant seems to produce their English /ɒ/ and /ɔ/ in the same manner, possibly distinguishing only quantity not quality, as it is for Czech /o/ and /oː/ (Skarnitzl and Volín 2012). Further, both high back vowels overlap in the two modes, if anything, it seems that the interpreting condition makes this speaker accommodate to the quality of Czech high back vowels, shifting further back (Skarnitzl and Volín 2012). English /ʌ/ also seems to be unshifted. On the other hand, a great diverging shift possibly occurs for the /ɑ/ vowel, which is moved further back as well, in accordance with its characteristics as reported by Bjelaković (2017). However, for this vowel there is only a single token in the interpreting condition, which needs to be taken into consideration.

The same trend of moving the production of English /u/ and /ʊ/ further back, as marginally seen in the vowel space of P10, is apparent even more for participant P5, especially for /ʊ/ vowel, producing a vowel more similar to Czech short /u/. Another shift towards Czech seems to occur in production of /ɑ/ vowel (F2: 1296.6 Hz), as it in the interpreting condition moves to more central position, corresponding to her Czech /aː/ (F2: 1523.4 Hz). The production of remaining vowels seems rather similar.

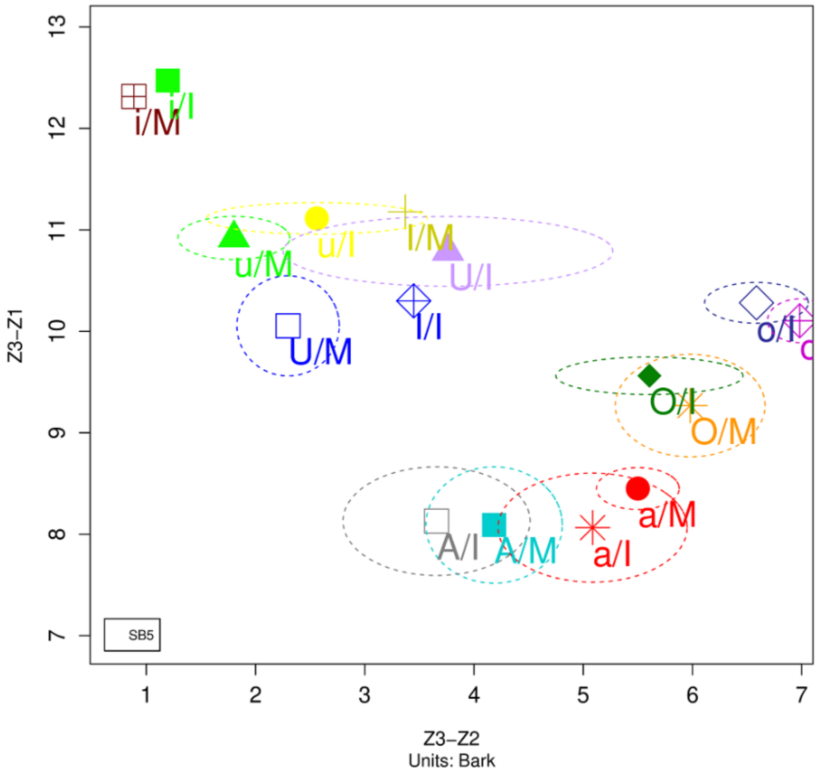

Figure 13: English production in two conditions (P5)

The figure shows English vowels produced by a participant P5 in two different conditions: bilingual interpreting and monolingual repetition condition. A symbol "M" marks a monolingual repetition mode, a symbol "I" marks bilingual interpreting mode. Capital letters marks letters English lax vowels, small letters mark English tense vowels. Namely, i, I, u, U, o, O, a, A marks English vowels /iː, ɪ, u, ʊ, ɔ, ɒ, ɑ, ʌ/ respectively. Thus, for example U/I refers to English lax /ʊ/ produced in an interpreting condition. The horizontal axis shows normalized front-back dimension (Z3-Z2), the vertical axis shows normalized height dimension (Z3-Z1), in Bark.

3.6. Discussion

3.6.1. Bilingual’s production in L1 and L2

The results showed that bilinguals as a group established new L2 categories for at least some of the investigated features. Based on comparison of VOT results in Czech monolingual and English monolingual mode, new L2 categories were created for all investigated stops /p, t, k/. When comparing bilinguals’ VOT values of their L2 stops to those reported for English native speakers, it appears the bilinguals approximated native like values with their average of 42 ms for /p/, and 71.9 for /k/, which are values approximately 10 ms lower than the average in Lisker and Abramson (1964, 394). In case of /t/ they even managed to reach 68.2 ms, which is only 1.2 ms away from the average referenced by Lisker and Abramson (1964, 394). As regards the vowel production, comparison of bilinguals’ production in Czech monolingual and English monolingual mode revealed that bilinguals have established separate categories for following English vowels: /u/, /ʊ/, and /ʌ/. Although visual representation suggests creation of categories for more vowels, other distinctions did not prove to be statistically significant, possibly even due to a high degree of variation in the data.

It was found that English tense /u/ was significantly more fronted than bilinguals’ long Czech /u:/, which suggests they noticed the more front quality of English /u/ as reported by Bjelaković (2017), although their group average for F2 of English /u/ (F1: 368.7 Hz; F2: 1560.0 Hz) was still lower than any of the mean F2 values reported for female speakers in Bjelaković’s (2017) study. The same tendency manifested in case of English /ʊ/ (F1: 462.0 Hz, F2: 1427 Hz), which was also significantly more fronted in comparison to their Czech short /u/, yet not more fronted that their English /u/ in accordance with the quality of the English vowels reported by Bjelaković (2017). For bilinguals’ English lax /ʊ/ and Czech short /u/ vowel pair there were found also significant differences in vowel height, English /ʊ/ being much more open than their Czech /u/. When roughly compared to the data collected by Bjelaković (2017), it seems that bilinguals average F1 values for /ʊ/ (F1: 462.0 Hz, F2: 1427 Hz) were very close to the average for all female speakers in Bjelaković’s (2017, 32) study (F1: 444.1 Hz, F2: 1491.7 Hz). Finally, their English /ʌ/ differed significantly from the Czech short /a/ (F1: 774.5 Hz; F2: 1438.7 Hz) in the front-back dimension, /ʌ/ having a more fronted quality (F1: 704.0 Hz, F2: 1509.0 Hz). As regards their production of this vowel, it seems the group produced even more fronted /ʌ/ than speakers in Bjelaković’s (2017) study or even in a study on American vowels conducted by Hillenbrand et al. (1995).

3.6.2. L1 Production: Bilinguals vs. Monolinguals

Further, comparing bilinguals' production in a monolingual Czech mode with production of functional monolingual control group, no significant differences between groups were found. The bilinguals seemed to have a somewhat higher VOT values for all their Czech stops, but the distinctions did not reach statistical significance. The differences in absolute VOT values were marginal for both Czech /p/ and /t/, bilinguals, with bilinguals' 15.3 ms /p/ and 20.9 ms /t/ and monolinguals' 14.2 ms /p/ and 20.2 ms /t/. The difference was more prominent for /k/ since bilinguals had VOT 34.3 ms and monolinguals 29.4 ms, although still not statistically significant. However, this may suggest that /k/ could be more susceptible to the interference. For example, in a study conducted by Schereschewsky, Alves, and Kupske (2017), /k/ was the only consonant to undergo attrition, which the authors explain by the fact that this stop was pronounced most accurately in their L2 and might have been easiest to learn for their speakers. Although the bilinguals in this study seemed to approximate English stops, their English /k/ showed the lowest dispersion from the stops, suggesting the bilinguals' category may be more stable than for English /p/ and /t/. Nevertheless, as described above, no significant group differences in VOT were found.

Identical results were obtained for Czech vowels, again, the bilingual group did not differ from the monolingual group. However, Euclidean distances were calculated, expressing the distance between bilinguals' Czech vowels and monolingual groups' averages for given vowels. Analysis of these distances indicated a high variation for some of the investigated vowels, marking a possibility of individual distances. Thus, individual analysis of these vowels, namely of Czech long central low /a:/ and short and long high back /u/ and /u:/ were conducted.

Several participants seemed to experience L1 interference motivated by their L2. For participants P1, P2, and P9 long Czech /u:/ was significantly more fronted than a monolingual average, a shift towards a quality of English tense /u/ with much higher F2 than typical for Czech (Bjelaković 2017; Skarnitzl and Volín 2012). The same assimilatory tendency (to English /ʊ/) was observed in production of short /u/ as well, again by participants P1 and P2. However, dissimilatory tendency manifested as well, in case of P10, who produced her short /u/ with a more back quality than the monolinguals, possibly aiming to ensure that her high back vowel categories are separate in the vowel space. Further, for long Czech /u:/, differences in height were observed as well, although the cause does not seem to be clear since if we look at data regarding vowel height of this corresponding pair as reported by Bjelaković (2017) for English and Skarnitzl and Volín (2012) for Czech, it seems that these vowels do not differ in vowel height, which was reflected even in bilinguals' production since distinctions in F1 for this vowel pair were minimal – e. g. for a group F1 of a Czech /u:/ was 364.5 Hz, for English /u/ it was 368.7 Hz. Such differences in F1 were found even for short Czech /u/, which similarly as English /u/ and Czech /u:/ vowel pair, does not seem to differ significantly in height from the English /ʊ/ based on means reported in Bjelaković (2017) and Skarnitzl and Volín (2012), although English /ʊ/ may have somewhat more open quality. For those speakers with different F1 for their corresponding English vowel, these changes may be motivated by either by maintaining a contrast (e. g. P7), if their Czech /u/ is more closed, or a shift to English, if they produce a more open Czech /u/. Finally, Participant P7 had a more fronted Czech long /a:/ vowel, the purpose might have been diverging from English back /ɑ/ (Bjelaković 2017), however, since this speaker's data for this vowel are not available, it can be only hypothesized. Differences in height of /a:/ were reported as well but since these are for speakers P1 and P7 with no tokens of English /ɑ/, it is rather difficult to make conclusions regarding the reasoning of these changes.

To summarize, bilinguals as a group performed indistinguishably from the monolingual group, however, we observed some individual differences that may indicate that L2 to L1 interference can manifest itself at least for some speakers in production of some vowels. It was hypothesized that L2 to L1 interference may occur for bilinguals in the study on the grounds of their L2 proficiency and by the nature of their major necessary contact with their L2. However, for them as a group, this was not confirmed.

Although we have seen that the interference manifested in case of bilinguals who live in an L1 dominant environment such as studies by Mennen (2004) or Schereschewsky, Alves, and Kupske (2017), it does not indicate that it has to occur in speech of all experienced L2 speakers or in case of all features. For example, in Schereschewsky, Alves, and Kupske's (2017) study, evidence of interference emerged for only one of the investigated phonemes. On the other hand, Mennen's study (2004) does not seem to specify the kind of L2 experience, providing only a number of years, so it may be that Mennen's participants e.g. lived in an L2 dominant country for a significant period time and thus are somewhat less comparable to bilinguals in this study, although that is just a speculation. Further, as suggested in a study conducted by Stoehr et al. (2017), it is contact with L1 that allows for participants to maintain a monolingual-like pronunciation, thus those with more L1 contact are less likely to experience L2 to L1 interference. However, most importantly, for speakers there are often individual differences. As illustrated by de Leeuw, Tusha, and Schmid (2018), for some, L2 interference (or attrition) can be so substantial that it leads to elimination of phonological contrast, whereas others pass as monolingual speakers. Even in Mennen's (2004) study one speaker had monolingual-like performance and the rest experienced bi-directional interference. That is supported by this study as well since when analyzing bilinguals' separate data, examples of L2 to L1 interference seem to emerge but only for individuals.

3.6.3. Dynamic changes in bilinguals' L1 and L2 production

The final aim was to determine whether interpreting, as a specific condition in which both Czech and English need to be activated to the same extent (Grosjean and Li (2013, 14–18) leads to bilinguals' category shifts. Production in both bilinguals' languages was investigated: Czech interpreting condition was compared to Czech monolingual condition, English interpreting condition was compared to English monolingual condition. However, no significant differences in production between the conditions were revealed, neither for Czech voiceless stop and vowel categories nor for corresponding English categories. The explanation behind this may lie in the fact that the bilinguals in this study were students of interpreting.

As Mora and Darcy (2017) note, pronunciation is linked to cognitive control and those with better cognitive abilities are likely to have more accurate pronunciation in L2. More specifically, one of the cognitive abilities is inhibitory control, which the bilinguals use to prevent language interference. Therefore, those with more developed inhibitory control, or in general cognitive abilities may be more immune to phonetic interference. As argued by Van der Linden et al. (2018) since language interference may have negative effects on interpreters' performance, e. g. when interpreting simultaneously, the interpreters need to master several cognitive control processes. In other words, interpreters may over time improve their cognitive abilities, including above discussed inhibitory control and thus be less susceptible phonetic to interference.

Nevertheless, as illustrated by vowel spaces of some individual speakers, whereas for some bilinguals there were no changes in production, for others, visual evidence of certain shifts emerged – which seemed to be motivated by the language that was activated yet not produced.

4 Conclusion

The present thesis investigated cross-linguistic influence in the speech of L1 Czech L2 English bilingual students of translation and interpreting. The theoretical part introduced a shift in the interest of interference studies towards an investigation of not only L1 to L2 interference but L2 to L1 interference as well (Pavlenko 2000) and summarized contemporary research questions and aspects on which the interference is commonly studied, with a focus on aspects investigated in the present study. Further, it described theoretical models that serve as a basis for numerous studies and finally, it provided an overview of findings collected by studies that investigate bi-directional interference.

The practical part of the study aimed to discover whether L1 Czech L2 English bilingual students of interpreting experience bi-directional interference. This was investigated on Czech and English voiceless stops /p, t, k/ and Czech back and central vowels /u, uː, o, oː, a, aː/ and back English vowels that were presumed to be perceptually equivalent /ʊ, u, ɒ, ɔ, ʌ, ɑ/. The research aims were threefold.

The first aim was to discover whether the bilinguals established new L2 categories for sounds with similar L1 counterparts, which was explored by comparing bilinguals' production in Czech and English. The results showed that bilinguals as a group created new categories for all English voiceless stops but only for some English vowels, namely for /u/, /ʊ/, and /ʌ/.

The second aim was to discover whether acquiring a new language lead to changes in bilinguals' L1 production. It has been shown by a number of studies, mostly interested in L1 attrition, that extended contact with L2 can result in changes in one's native pronunciation even for late learners (e. g. Bergmann et al. 2016; de Leeuw, Tusha, and Schmid 2018; Mayr, Price and Mennen 2012). However, investigation of late bilinguals who learned their L2 in classrooms and live an L1 dominant country appears to be less frequent. The bilinguals in this study, that is students of interpreting and translation, by the nature of their study major need to be both highly proficient in English and in a frequent contact with this language. Therefore, it was hypothesized that interference may occur in their L1 speech. The effects of L2 were investigated by comparing bilinguals' Czech speech production to a production of a functional monolingual group. The results did not reveal any significant differences in production for bilinguals as a group, however, a closer analysis of individual results revealed differences in production of Czech long central low /a:/ and short and long high back /u/ and /u:/ for some speakers.

The final aim was to reveal whether a different degree of activation of languages leads to category shifts. That was investigated by comparing bilinguals’ performance in two conditions: repetition task and interpreting task. The repetition task represented a monolingual mode, that is a situation when bilingual activates only the language produced, whereas the interpreting task indicated bilingual mode, in which both languages are activated to the same extent (Grosjean and Li 2013, 14–18). The possible category shifts were investigated both for Czech production, that is by comparing Czech monolingual production and Czech production when interpreting from English, and for English production. However, the results did not reveal any significant differences in bilinguals’ production under these two different conditions. A possible explanation for absence of category shifts is a greater inhibitory control, as discussed by Mora and Darcy (2017), due to the participants’ interpreting experience Van der Linden et al. (2018).

5 Resumé

Tato diplomová práce se zabývá mezijazykovým vlivem, konkrétně možností manifestace fonetické interference. V minulosti se fonetické výzkumné studie soustředily na zkoumání výskytu cizího přízvuku v nově osvojeném jazyce, avšak dnes je již prokázáno, že stejně jako rodný jazyk ovlivňuje řečovou produkci v jazyce cizím, cizí jazyk může ovlivnit i jazyk rodný (Pavlenko 2000). Vliv druhého osvojeného jazyka na rodný jazyk je pozorován i u pozdně bilingvních mluvčích, avšak výzkum se zaměřuje spíše na mluvčí, kteří se přestěhovali do prostředí, ve kterém dominuje jejich druhý osvojený jazyk (e. g. Bergmann et al. 2016; de Leeuw, Tusha, and Schmid 2018; Major 1992). Z tohoto důvodu si tato práce kladla za cíl prozkoumat, zda se interference projeví i v českém prostředí, u mluvčích, kteří se cizí jazyk naučili studiem ve školách, a ne prostřednictvím každodenního kontaktu s jazykem v důsledku pobytu v cizí zemi.

Ve rámci teoretické části diplomová práce shrnuje cíle současného bádání v této oblasti, studované aspekty (se zaměřením na aspekty zkoumané v předkládaném výzkumu), teoretické modely, ke kterým řada badatelů odkazuje, a dále sumarizuje studie zkoumající obousměrnou fonetickou interferenci. Praktická část pak zkoumá produkci řeči pozdně bilingvních mluvčích žijících v prostředí, kde dominuje jejich rodný jazyk, s cílem odpovědět na řadu výzkumných otázek. Zkoumanými aspekty jsou neznělé české a anglické explozivy /p, t, k/ a české zadní a centrální samohlásky /u, u:, o, o:, a, a:/ a jejich ekvivalentní anglické protějšky, zadní samohlásky /ʊ, u, ɒ, ɔ, ʌ, ɑ/.

První výzkumnou otázkou bylo, zda si bilingvní mluvčí, v našem případě studenti tlumočení a překladu v kombinaci čeština-angličtina, vytvořili nové kategorie pro zkoumané hlásky. Při porovnání jejich produkce řeči v češtině a angličtině bylo zjištěno, že si studenti vytvořili nové kategorie pro veškeré anglické explozivy /p, t, k/, avšak ne pro všechny samohlásky, ale pouze pro anglické vysoké zadní samohlásky /u, ʊ/ a centralizované zadní /ʌ/.

Druhá výzkumná otázka měla za cíl zjistit, zda došlo k posunu fonetických kategorií v rodném jazyce bilingvních mluvčích, tedy v češtině, a sice porovnáním jejich české řečové produkce s produkcí českých funkčně monolingvních mluvčích. Bylo zjištěno, že bilingvní mluvčí se jako skupina nijak nelišili od mluvčích monolingvních, avšak po podrobnější analýze některých individuálních rozdílů se potvrdilo, že produkce zadních vysokých samohlásek /u, u:/ a centrálního nízkého /a:/ některých mluvčích se významně odchýlila od průměrných hodnot pro české funkčně monolingvní mluvčí. Tudíž se dá předpokládat, že alespoň někteří mluvčí byli ovlivněni osvojením druhého jazyka.

Poslední výzkumná otázka se týkala úrovně aktivace jazyků bilingvních mluvčích. Bylo předpokládáno, že současné aktivování obou jazyků, které je typické pro tlumočení, by mohlo vést k vyšší míře mezijazykové interakce, a tudíž k určitému posunu fonetických kategorií, v porovnání se situací, kdy bilingvní mluvčí aktivuje pouze jeden jazyk, ve kterém v danou dobu probíhá produkce řeči (Grosjean and Li 2013, 14–18). Tyto možné dynamické posuny kategorií byly zkoumány jak pro češtinu, tak pro angličtinu, a sice porovnáním produkce zkoumaných hlásek v monolingvním módu založeném na opakování a v módu bilingvním tlumočnickém (Grosjean and Li 2013, 14–18). Analýza dat však neodhalila žádné statisticky významné rozdíly mezi těmito dvěma módy, což by se dalo vysvětlit prostřednictvím lepších kognitivních schopností inhibiční kontroly pramenící ze statusu tlumočníků (Mora and Darcy 2017, Van der Linden et al. 2018).

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7 Appendix

P	Age	Educational Attainment	Languages that you learned (apart from English)	Start of learning of English (grade/age)	Additional English education (in the past)	Have you lived in an EN speaking country? (longer than 1 year)
P1	25	secondary	Latin – beginner	4th grade/10 years	–	No
P2	22	secondary	German – beginner	4th grade/?	excursions abroad twice a week	No
P3	27	secondary	German – absolute beginner	4th grade/10 years	–	No
P4	21	secondary	Russian – pre-intermediate	3rd grade/8 years	English course (2 hours/week)	No
P5	22	secondary	French, German, Russian – absolute beginner	1st grade/6 years	English course (2hours/week) for 4 years	No
P6	22	secondary	German – absolute beginner	3rd grade/8years	English course (1 hour/week)	No
P7	29	secondary	–	5th grade/10-11 years	–	No
P8	25	university	–	?/11 years	Extra classes (1hour/week) for half a year	No
P9	24	secondary	? – absolute beginner	3rd grade/?	English course (90minutes/week) for 1 year	No
P10	20	secondary	Russian – absolute beginner German – beginner	?/8years	–	No
P11	21	secondary	German – beginner Russian – absolute beginner	3rd grade/8 years	–	No
P12	20	secondary	German – absolute beginner	3rd grade/8 years	–	No

Table 11: Monolinguals – Basic information

The table contains basic information about functional monolingual speakers translated from a Czech questionnaire distributed to the participants.

P	Do you currently take an English course?	If not, when it is the last time you learned English?	How often do you encounter with English texts?	How often do you encounter with English in the media?	How often do you encounter with speakers of English?	How often do you write texts in English?
P1	–	5 years ago (high school)	daily	(almost) never	(almost) never	(almost) never
P2	–	2019 (university)	weekly	(almost) never	(almost) never	(almost) never
P3	–	7 years ago (high school)	daily	(almost) never	(almost) never	(almost) never
P4	English course 2 hours/week	–	(almost) never	(almost) never	(almost) never	(almost) never
P5	–	1 year ago (univ.)	weekly	daily	weekly	(almost) never
P6	–	2019 (univ.)	weekly	weekly	(almost) never	(almost) never
P7	–	9 years ago	weekly	weekly	(almost) never	monthly
P8	–	1,5 years ago	monthly	monthly	(almost) never	(almost) never
P9	–	1 year ago (univ.)	daily	weekly	(almost) never	(almost) never
P10	university course	–	daily	daily	(almost) never	weekly
P11	–	1 year ago (univ.)	monthly	weekly	monthly	(almost) never
P12	–	1 year ago (univ.)	monthly	(almost) never	(almost) never	(almost) never

Table 12: Monolinguals – Contact with English

The table contains information on amount of contact with English of functional monolingual speakers. The information was translated from a Czech questionnaire which was distributed to the participants.

P	Would you be able to give directions to a native speaker?	Skills self-rating: 1 – the lowest , 7 – the highest				Are you motivated to learn English?	Do you currently work on improving your English?
		Listening	Reading	Conversation	Writing		
P1	yes, with problems	2	2	1	1	yes	no
P2	yes, but most likely with problems	2	3	1	1	no	no
P3	yes, with problems	4	5	2	2	yes	English movies and series, books
P4	probably, with problems	3	5	2	1	yes	self-study
P5	yes, without a problem	6	5	5	4	no	no
P6	it would be a problem, (with gestures)	3	3	4	2	yes	no
P7	probably not	2	2	1	1	no	no
P8	yes, but not a fluent conversation	3	3	3	2	yes	self-study
P9	yes, but with problems	2	4	2	4	yes	no
P10	no	3	4	3	3	yes	no
P11	probably, but with grammatical mistakes	4	5	4	3	yes	no
P12	probably, with problems (gestures)	2	3	1	1	no	no

Table 13: Monolinguals – Self-evaluation of skills and motivation

The table contains information on the (lack of) proficiency of functional monolingual speakers. The information was translated from a Czech questionnaire that was distributed to the participants.

P	Age	Year of study	Other languag e(s) spoken fluently	Age at onset of learning of this language	The frequency of active use of this language	The frequency of passive exposure to this language	Recent participati on in an intensive language course	Recent stay in a foreign speaking country
P1	27	extending the study period	Spanish	15	several times a year	several hours a month	–	–
P2	25	second year	–	–	–	–	–	–
P3	26	extending the study period	–	–	–	–	–	2 years ago Italy (semester)
P4	24	second year	–	–	–	–	–	–
P5	25	extending the study period	–	–	–	–	–	–
P6	25	extending the study period	Polish	Czech-Polish simultaneous bilingual	several hours a week	daily	–	3 years ago England (5months)
P7	27	second year	German	15	several times a year	several times a year	–	–
P8	25	second year	French	12	several times a year	several times a month	–	–
P9	26	extending the study period	–	–	–	–	Mandarin Chinese (12 weeks)	China (5 months)
P10	25	extending the study period	–	–	–	–	–	–

Table 14: Bilinguals – Basic information

The table contains basic information about bilingual participants in this study collected through a questionnaire.

P	Age and grade at onset of learning of English at school	Age of exposure to English before onset of learning at school	Attended an elementary school with extended language instruction	Attended a grammar school with extended language instruction	Attended a bilingual grammar school	Additional instruction in English
P1	3rd grade/9 years	kindergarten/4-5 years	no	no	no	conversation with a native speaker, summer language school
P2	3rd grade/8 years	–	no	no	no	Institute for Language and Preparatory Studies
P3	kindergarten/5 years	–	no	no	no	language school
P4	1st grade/6 years	–	no	no	no	English camp every summer for a week
P5	3rd grade/9 years	6 years	no	no	no	–
P6	3rd grade/8 years	–	no	no	Polish-Czech	language courses, summer language school
P7	4th grade/10 years	–	no	no	no	–
P8	4th grade/10 years	–	yes	yes	no	–
P9	3rd grade/?	7-8 years	no	yes	yes	summer language school in Canada
P10	?/9 years	–	yes	no	no	–

Table 15: Bilinguals – Onset of learning English

The table contains information on onset of learning English and English language experience of bilingual participants collected through a questionnaire.

P	English taught by a native speaker apart from university (in years)	Significant amount of time spent in an English-speaking country before the age of 15	Significant amount of time spent in an English-speaking country after the age of 15	Age at which you started to feel comfortable using English	Amount of time spent interacting with native English speakers (apart from school)	Frequency of exposure to the English-speaking media
P1	5 to 10 years	–	–	15–17	several times a week	daily – up to 1 hour
P2	–	–	–	20	several times a year	daily – up to 1 hour
P3	–	–	3 (almost 4) months	13	several times a week	daily – more than 2 hours
P4	–	–	10 months	15–16	several times a month	daily – 1 to 2 hours
P5	–	–	–	17	none	several hours a month
P6	–	–	5 months	13–14	several times a year	daily – more than 2 hours
P7	4 years	–	3 months	18	several times a week	daily – 1 to 2 hours
P8	1 year	–	10 months	14	several times a month	daily – more than 2 hours
P9	–	2 months (when turning 15)	–	18	several times a year	daily – 1 to 2 hours
P10	–	–	–	17	none	several hours a week

Table 16: Bilinguals – Contact with English

The table contains information on bilingual participants’ contact with English collected through a questionnaire.

P	Foreign accent in English self-rating	Rating of the importance of improving one's own pronunciation	Self-rating of an active focus on improving one's pronunciation	Number of attended interpreting seminars at the university	Experience with interpreting apart from university	Current frequency of interpreting	Interest in improving one's interpreting ability	Active work on improving interpreting skills	Previous participation in a phonetic research
	1 – none /not important/ not at all 7 – heavy/ very important/immensely								
P1	3	7	6	10	yes	several times a month	yes	yes	yes
P2	5	5	4	9	yes	(almost) never	maybe	no	yes
P3	2	4	4	10	yes	several times a year	yes	no	yes
P4	3	7	5	9 or 10	yes	several times a month	yes	no	no
P5	6	7	4	10	yes	several times a year	yes	no	yes
P6	6	6	3	8	no	(almost) never	yes	no	yes
P7	3	7	5	8	yes	several times a year	no	no	yes
P8	3	2	2	5	yes	several times a year	no	no	yes
P9	2	6	4	7	no	(almost) never	no	no	yes
P10	5	6	3	10	no	(almost) never	no	no	yes

Table 17: Bilinguals – Interpreting experience and accent self-ratings

The table contains information on bilingual participants' interpreting experience and accent self-ratings, the information was collected through a questionnaire administered to the bilinguals.

Informovaný souhlas

Název výzkumu: Mezijazykový vliv druhého jazyka na jazyk mateřský v řeči pozdně bilingvních mluvčích

Řešitel výzkumu: Tereza Šreková

Název pracoviště: Katedra anglistiky a amerikanistiky, Univerzita Palackého v Olomouci

Vedoucí práce: Mgr. Šárka Šimáčková, Ph.D.

Popis/účel výzkumu

Jedná se o fonetický výzkum, který se zabývá mezijazykovým vlivem. Cílem výzkumu je prozkoumat, zda (a jakým způsobem) osvojení cizího jazyka ovlivní produkci řeči v jazyce mateřském.

Metody

Účastníkům tohoto výzkumu budou prezentovány věty, které bude mít za úkol opakovat, případně tlumočit. Produkce těchto vět účastníka bude nahrána a dále zpracována. Dále budou účastníci požádáni o vyplnění dotazníku týkajícího se jejich jazykových zkušeností, případně testu týkajícího se znalostí slovní zásoby v cizím jazyce.

Rizika

Účast na výzkumu s sebou nenese žádná rizika poškození zdraví.

Práva účastníků

Účast na výzkumu je dobrovolná, lze ji kdykoliv přerušit a bez udání důvodu výzkum opustit.

Zachování důvěrnosti osobních údajů

Účast ve výzkumu nepovede ke ztrátě soukromí. Při provádění a zpracovávání studie budou osobní údaje poskytnuty pouze výše uvedeným osobám. Výsledky tohoto výzkumu pak budou přístupny dalším osobám (v rámci diplomové práce, dalších výzkumů, prezentací apod.), avšak pouze v podobě anonymních dat. Jinými slovy, v případě uvedení individuálních výsledků nebude možné dané údaje spojit s konkrétní osobou.

Souhlas účastníka se zapojením do výzkumu

Prohlašuji a svým níže uvedeným vlastnoručním podpisem potvrzuji, že jsem si tento formulář řádně přečetl/a a že dobrovolně souhlasím s účastí ve výše uvedeném výzkumu.

Jméno a příjmení účastníka: …………………………………. Datum: ………………

Podpis účastníka: …………………………………

Variable	Mean (m)	Mean (b)	t-value	df	p	Valid N m	Valid N b	Std. Dev. m	Std. Dev. b	F-ratio Variances	p Variances
F1 /o/	9.94900	9.70810	0.817044	20	0.423530	12	10	0.641809	0.741803	1.335874	0.640399
F2 /o/	5.84767	5.56260	1.145378	20	0.265574	12	10	0.555198	0.611626	1.213601	0.749565
F1 /o:/	9.73683	9.61680	0.508540	20	0.616639	12	10	0.528329	0.578052	1.197082	0.765626
F2 /o:/	5.88217	5.66380	0.991650	20	0.333215	12	10	0.581541	0.417635	1.938949	0.329504
F1 /u/	11.26425	11.20820	0.266443	20	0.792625	12	10	0.425623	0.561236	1.738765	0.382837
F2 /u/	6.20567	5.96410	0.759979	20	0.456133	12	10	0.575328	0.905597	2.477647	0.158142
F1 /u:/	11.37267	11.32460	0.239757	20	0.812959	12	10	0.371220	0.564583	2.313095	0.190984
F2 /u:/	7.14325	6.74470	1.022785	20	0.318622	12	10	0.789264	1.038827	1.732374	0.385925
F1 /a/	8.53208	8.42130	0.528568	20	0.602922	12	10	0.467844	0.514733	1.210491	0.752564
F2 /a/	4.53650	4.41310	0.579190	20	0.568928	12	10	0.444270	0.555861	1.565449	0.476851
F1 /a:/	8.05575	7.68150	1.397776	20	0.177493	12	10	0.611001	0.642391	1.105388	0.860752
F2_/a:/	4.19792	3.92620	1.315166	20	0.203334	12	10	0.471944	0.495139	1.100713	0.865878

Table 18: T-Tests (Monolingual vs. Bilingual group)

The table shows results of T-Tests (Independent by Group) which were supposed to validate whether bilinguals and monolinguals produce Czech vowels differently. Mean values in the table are in Barks, “m” symbolizes monolinguals, “b” symbolizes bilinguals.

Variable (F1)	Mean (in Bark)	Std. Dv.	N	Diff.	Std. Dv. Diff.	t	df	p	Confidence -95.000%	Confidence +95.000%
/o/ – M	9.70810	0.741803								
/o/ – I	9.64410	0.605965	10	0.06400	0.851819	0.2376	9	0.817518	-0.54535	0.67335
/o:/ – M	9.61680	0.578052								
/o:/ – I	9.40530	0.621447	10	0.21150	0.901892	0.7416	9	0.477248	-0.43367	0.85667
/u/ – M	11.20820	0.561236								
/u/ – I	11.20300	0.366853	10	0.00520	0.357220	0.0460	9	0.964289	-0.25034	0.26074
/u:/ – M	11.32460	0.564583								
/u:/ – I	11.30630	0.651170	10	0.01830	0.545211	0.1061	9	0.917798	-0.37172	0.40832
/a/ – M	8.42130	0.514733								
/a/ – I	8.15610	0.488877	10	0.26520	0.598070	1.4022	9	0.194381	-0.16263	0.69303
/a:/ – M	7.68150	0.642391								
/a:/ – I	7.49680	0.844119	10	0.18470	0.964663	0.6055	9	0.559824	-0.50538	0.87478

Table 19: Dependent Sample T-Tests (Mode comparison)

The table shows results of a Dependent Sample T-Tests for F1 of Czech vowels produced under two different experimental conditions: a condition of interpreting from English into Czech and a monolingual Czech repetition condition. The Capital "M" marks a vowel produced in a monolingual condition, the capital "I" marks a vowel in an interpreting condition. The mean values are in Bark.

Variable (F2)	Mean (in Bark)	Std. Dv.	N	Diff.	Std. Dv. Diff	t	df	p	Confidence -95.000%	Confidence +95.000%
/o/ – M	5.562600	0.611626								
/o/ – I	5.694400	0.481930	10	-0.13180	0.538235	-0.7744	9	0.458576	-0.51683	0.25323
/o:/ – M	5.663800	0.417635								
/o:/ – I	5.729800	0.535575	10	-0.06600	0.560256	-0.3725	9	0.718122	-0.46678	0.33478
/u/ – M	5.964100	0.905597								
/u/ – I	6.060700	0.551628	10	-0.09660	0.520563	-0.5868	9	0.571750	-0.46899	0.27579
/u:/ – M	6.744700	1.038827								
/u:/ – I	6.666900	0.953202	10	0.07780	0.791608	0.3108	9	0.763036	-0.48848	0.64408
/a/ – M	4.413100	0.555861								
/a/ – I	4.233800	0.603872	10	0.17930	0.380617	1.4897	9	0.170494	-0.09298	0.45158
/a:/ – M	3.926200	0.495139								
/a:/ – I	3.768700	0.487264	10	0.15750	0.401751	1.2397	9	0.246429	-0.12990	0.44490

Table 20: Dependent Sample T-Tests (Mode comparison)

The table shows results of a Dependent Sample T-Tests for F2 of Czech vowels produced under two different experimental conditions: a condition of interpreting from English into Czech and a monolingual Czech repetition condition. The Capital "M" marks a vowel produced in a monolingual condition, the capital "I" marks a vowel in an interpreting condition. The mean values are in Bark.

Variable (F1)	Mean (in Bark)	Std. Dv.	N	Diff.	Std. Dv. Diff	t	df	p	Confidence -95.000%	Confidence +95.000%
/ɒ/ – M	8.36330	1.256906								
/ɒ/ – /I	8.55170	0.756358	10	-0.18840	0.651214	-0.91487	9	0.384118	-0.65425	0.27745
/ɔ/ – M	8.70830	1.047636								
/ɔ/ – I	8.68420	0.887196	10	0.02410	0.737907	0.10328	9	0.920006	-0.50377	0.55197
/ʊ/ – M	9.93010	0.723208								
ʊ/ – I	10.04840	0.701900	10	-0.11830	0.377583	-0.99077	9	0.347686	-0.38841	0.15181
/u/ – M	10.97800	0.448745								
/u/ – I	10.89920	0.548335	10	0.07880	0.604961	0.41191	9	0.690045	-0.35396	0.51156
/ʌ/ – M	8.22560	0.703771								
/ʌ/ – I	7.99590	0.363645	10	0.22970	0.631441	1.15034	9	0.279649	-0.22201	0.68141
/ɑ/ – M	7.93325	0.608033								
/ɑ/ – I	7.66175	1.029145	8	0.27150	0.762098	1.00764	7	0.347183	-0.36563	0.90863

Table 21: Dependent Sample T-Tests (Mode comparison)

The table shows results of a Dependent Sample T-Tests for F1 of English vowels produced under two different experimental conditions: a condition of interpreting from Czech into English and a monolingual English repetition condition. The Capital "M" marks a vowel produced in a monolingual condition, the capital "I" marks a vowel in an interpreting condition. The mean values are in Bark.

Variable (F2)	Mean (in Bark	Std. Dv	N	Diff	Std. Dv. Diff	t	df	p	Confidence -95.000%e	Confidence +95.000%
/ɒ/ – M	4.906000	0.792282								
/ɒ/ – /I	5.083500	0.573650	10	-0.17750	0.475428	-1.1806	9	0.268010	-0.51760	0.16260
/ɔ/ – M	5.596900	0.895374								
/ɔ/ – I	5.799600	0.909831	10	-0.20270	0.739140	-0.8672	9	0.408350	-0.73145	0.32605
/ʊ/ – M	3.819000	1.214240								
ʊ/ – I	4.204600	1.055870	10	-0.38560	0.503882	-2.4200	9	0.038613	-0.74606	-0.02514
/u/ – M	3.517800	1.377836								
/u/ – I	3.745500	0.812293	10	-0.22770	0.829133	-0.8684	9	0.407715	-0.82083	0.36543
/ʌ/ – M	3.648700	0.581458								
/ʌ/ – I	3.730800	0.391684	10	-0.08210	0.443654	-0.5852	9	0.572796	-0.39947	0.23527
/ɑ/ – M	4.648250	0.524590								
/ɑ/ – I	4.704000	0.924574	8	-0.05575	0.829304	-0.1901	7	0.854595	-0.74907	0.63757

Table 22: Dependent Sample T-Tests (Mode comparison)

The table shows results of a Dependent Sample T-Tests for F2 of English vowels produced under two different experimental conditions: a condition of interpreting from Czech into English and a monolingual English repetition condition. The Capital "M" marks a vowel produced in a monolingual condition, the capital "I" marks a vowel in an interpreting condition. The mean values are in Bark.