Filozofická fakulta Univerzity Palackého

Phonetic changes of Voice Onset Time and vowel duration in Czech and Canadian English bilinguals' speech

An acoustic study

(Bakalářská práce)

2018 **David Ryška**

Filozofická fakulta Univerzity Palackého
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Fonetické změny ve VOT a samohláskové délce u česko-anglických dvojjazyčných subjektů – Akustická studie

(Bakalářská práce)

Autor: **David Ryška**
Studijní obor: Anglická filologie
Vedoucí práce: **Mgr. Václav Jonáš Podlipský, Ph.D.**
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V Olomouci dne 11.6.2018 **David Ryška**

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Abstract

Two L1 (Canadian English) dominant bilinguals (12 and 16 years old) are recorded twice two months apart (just after their arrival in the Czech Republic, and just before their departure back to Canada) to determine wheter a recent experience in purely Czech speaking environment changes their L1 and/or L2 on a phonetic level. The focus is on VOT (Voice Onset Time) and vowel duration. The participants are asked to read aloud words, which are being displayed in front of them in controlled intervals. These recordings are later analysed using Praat, measuring the VOT, and the lenght of vowels in both English and Czech, and then submitted to STATISTICA software for ANOVA analysis. Results of this experiment have shown a succesfull Gestural Drift for both subjects VOT in English and Czech towards hypothesised outcome, vowel duration experiment did however not supported the initial hypothesis and no significant changes were present after the immersion.

Key words

VOT (Voice Onset Time), plosive, bilingualism, vowel lenght,

Anotace

Dvě zkoumané dvojjazyčné sestry s dominantním Anglickým jazykem jsou nahrány dvakrát s dvouměsíčním intervalem (ihned po jejich příjezdu do České republiky a těsně před jejich odletem zpět do Kanady), se záměrem zjistit, zda-li dva měsíce v čistě česky mluvícím prostředí ovlivní jejich VOT jak v jazyku dominantním, tak sekundárním, a to na fonetické úrovni. Obě účastníce této studie jsou instruovány ke čtení slov, která se před nimi objevují na obrazovce v kontrolovaných intervalech. Tyto nahrávky jsou později analyzovány v programu Praat, kde jsou měřeny změny v jejich VOT a délce samohlásek u anglických i českých slov, a dále jsou výsledky analyzovány pomocí analýzy rozptylu (ANOVA) v programu STATISTICA. Výsledky této práce odhalily úspěšný posun ve VOT obou subjektů v anglickém i českém jazyce ve směru shodném s hypotézou, experiment zabývající se samohláskovou délkou ovšem neposkytl žádná signifikantní výsledky které by byly shodné s hypotézou.

Klíčová slova

VOT, plozíva, dvojjazyčnost, samohlásková délka,

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1 Introduction

With nearly seven and a half billion people on this planet, bilingualism is becoming more and more frequent. Living without any knowledge of a foreign language has become significantly harder than in the past. With people traveling and migrating more often every day, the number of children with more than one native language has rapidly risen. And it is the bilingual children, with exposure to two completely different languages, cultures and traditions, that create the core of this thesis.

This thesis presents a case study of two young imbalanced bilingual speakers‘ pronunciation after 2-month immersion in their weaker language speaking environment…. Subjects for this thesis are Czech and Canadian English bilinguals, sisters, author's cousins (13 and 16 years old during the experiment). Mother is native Czech, father is native Canadian. Subjects were both born in Toronto, Ontario, Canada and have never lived in the Czech Republic for a period longer than 3 months. When the sisters were younger (around 9 and 6 years), their Czech language was much more balanced in proficiency with English, but then I started to witness the eventual decreasing of Czech, despite being exposed to the language by one of their parents. And during spontaneous conversation, their comprehension, e.g. their ability to understand conversation in L2 was radically higher than their expression, e.g. their ability to produce grammatical sentences in L2, i.e. they understood Czech, but when asked to translate a Czech sentence into English, both struggeled to do so.When asked to read aloud a random sentence from Czech children's book, within two days since their arrival in the Czech Republic, prior to the experiment, both failed to read or understand it. But when I read the same sentence out loud to the subjects separately, and then asked them to interpret the meaning, they both succeeded. They did not show any problem with reading in English. Adler wrote that it is very hard to exactly state how much is a person's bilingualism tilted towards one or another of his languages, whether it is 40, 20 or even 5 percent (1977, 5). Due to this complicated degree of bilingualism and potentional interarction between their L1 and L2, this thesis will focus on the influence of L2 on L1 and the overall improvement of L2 after a recent experience in the Czech Republic.

This thesis is divided into two parts, with part one being the theoretical background the topic of phonetic drifts induced by changes in the ambient language surroundings, next, the domain of bilingualism in terms of phonetic subsystems of L1 and L2, and the second part will be a comparative experiment focusing on the acoustic changes of word initial stop consonants and intervocalic vowels. Each of the subjects will be recorded, given a set of monosyllabic and polysyllabic words both in English and in Czech, then will be asked to read those words in controlled intervals. This task will be carried on immediately after subjects' arrival in the Czech Republic and then repeated just before their departure back to Canada, with the same set of words. Then the recordings of the words will be analysed and compared on the acoustic phonetic level, focusing on the changes in VOT (Voice Onset Time) and the changes in duration of vowels. This experiment aims to show how the weaker language, in this case Czech, improves after short-term immersion, and whether the VOT and vowel duration becomes closer to that of native Czech, and second, how the dominant language, in this case English, is influenced, when the subjects are spending time in Czech speaking environment. Furthermore, it may help to understand, how are the two languages organised in the minds of these bilinguals, whether they are two separated systems or one, big system with two mutually interacting parts (see Section 2.5). Charlotte (1991) is talking mainly about these interactions between the bilingual's languages.

> If one holds the view that a bilinguial is, linguistically speaking, a composite containing two seperate parts (or codes), then the basis for assessing his language competence will be monolingual standards of proficiency in the use of the two systems. In this case, notions of the purity of the language will be rated more higly than those of communicative competence. (Charlotte, 1991, 94

Given the data, over two months and two recording sessions, the aim of the experiment is to find out if recent experience in L2 environment affects the L1, namely VOT and vowel duration, with focus on the positive influence on L2 and its improvement. Since I will primarily be focusing on two bilingual children aged 13 and 16 years, Every recorded utterance will be analysed and labeled, which will be the data source for the second half of this thesis. In this section the recorded samples will be divided and the goal is to compare the samples with each other in various combinations to determine, what has the most significant influence on the duration of the studied intervals (VOT and vowel duration). Once my subjects are specifically defined and selected, they are familiarized with the words used for the experiment. Given the fact that their exposure to L2 is limited only to their mother, who they live with in Canada, their grandparents‘ one-month visit every January and their eight-week long visit in the Czech Republic every summer, the Czech words used are all translated for the subjects.

Over all, this thesis should provide a conprehensible analysis and description of the main acoustic changes in the duration of both Czech and English vowels and the changes in Voice Onset Time in stop initial words in both languages, that these bilinguals go through, when exposed to a Czech speaking environment.

2 Theoretical Background

2.1 Voice Onset Time (VOT)

In Yavas (2004), VOT is defined as the time, that elapses between the release of the closure of a stop consonant, and the beginning, or the onset, of the vocal cord vibrations (that is part of the following sonorant speech sound). VOT also categorizes as the primary cue when destinguishing English voiced and voiceless phonemes in produced speech. Miller, Green and Reeves (1986) discussed the mutual relation between speech production and perception in terms of recognising voicing contrast, e.g. correctly distinguishing voiced and voiceless allophones of /b/ and aspirated and unaspirated allophones of /p/. (108,112) and what did they say, or why do you mention them? The difference between Czech VOT and English VOT is for both voiced and voiceless plosives (Šimek, 2010; Abramson and Lisker, 1964; Chen et al., 2007). For syllable-initial English voiced stops, the voicing is said to start immediately after the release of the articulators, resulting in short to zero VOT (Macken and Barton, 1977). For voiceless stops, the lenght of VOT differes depending on whether it occurs in a stressed or unstressed syllable, on the place of articulation (the shorter the smaller the volume of the vocal tract) speech tempo, etc.(82). In a stressed syllable, the burst is followed by a long release of acumulated air ranging from -60ms to -100ms (Macken and Barton, 1987), called an aspiration. For unstressed syllables, the aspiration is not present and the VOT is rather shorter, ranging from 0 to 25ms after the release. (Abramson and Lisker, 1964: 392, 394; Macken and Barton 1987, 4). English can thus be described as an aspirating language (short-lag vs long-lag ….) These types of languages are called aspirating. For Czech words beginning with voiced stops /b, d, ɟ, g/, the vibration of the vocal cords begins before the release of the articulators, resulting in interval of periodicity called prevoicing, e.g. negative VOT. Czech language belongs to voicing languages, i.e. languages that have negative VOT for voiced word-initial stops. For their voiceless counterparts /p, t, k/, the VOT is similar to the one of English, but is shorter and aspiration is absent both stressed and unstressed syllables. Šimek (2010) and Machač (2006) conduct experiments measuring the mean duration of VOT in Czech plosives and comparing it according to the position of the plosive in the syllable. The VOT for stops in initial position was around 93,7ms on average for voiceless stops and 65,5ms on average for voiced plosives (Šimek, 2010, 39). The prevoicing that occured in this experiment and thus the negative VOT duration was ranging from 70 to 100ms.

2.1.1 Aspiration

When talking about stops, sometimes also called plosives, we must also talk about aspiration. It is a common phenomenon in English language, typical for voiceless stop consonants in stressed syllables. Ladefoged and Johnson (2014, 61) define it as the period of voicelessness after the stop articulation and before the start of the voicing of the vowel. It is the additional stream of air present after the release of the articulators, caused by the delay of the onset voicing. In English, aspiration only occurs in voiceless stop consonants, making it the main distinguishing feature between their voiced counterparts, as shown in Figure 2.

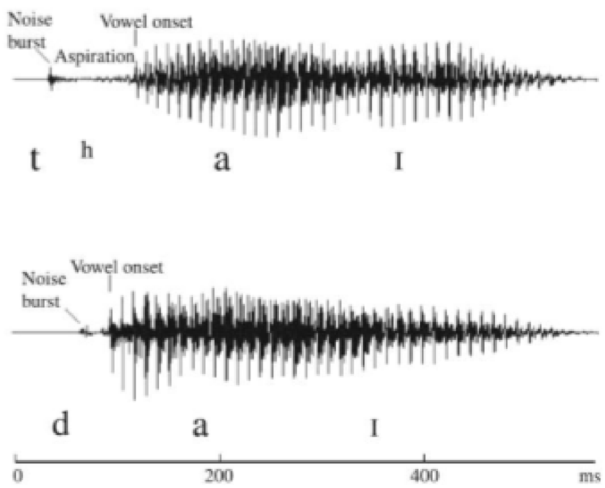

Fig.2: Voicing contrast between /t/ and /d/. (Ladefoged & Johnson,2014, 62)

A figure showing how the VOT interval is measured?

2.2 The Phonology of Canadian English

Canada, the largest member of the Commonwealth of Nations geographically, has two official languages, English and French. Roughly two thirds of the population have English as their native language (Wells, 490). The standard Canadian accent may be easily confused with GA (General American), and despite some phonetic differences fron GA, Canadian English is much closer to GA, then to RP (Wells, 491). There are, nevertheless, some phonetic differences between Canadian English and other varieties of the English language.

2.2.1 Stop consonants in English

Canadian English, as discussed later, has number of phonetic distinctions from GA. Despite that, the consonants of Canadian English (CA) remainvirtually identical with those of GA. In terms of stop consonants, CA has three main types. Bilabial stops occur when airstream is blocked by upper and lower lip (/b/, /p). Alveolar stops are created by tip of the tongue and the alveolar ridge and obstruing the airflow (/t/, /d/). Velar stops (/k/ and /g/) are created at the back of the oral cavity by the back of the tongue and soft palate (Ladefoged and Johnson, 2014, 12-14)

Nasal stops (bilabial /m/, alveolar /n/ and velar /ŋ/) must also be taken into consideration, although the airstream is not blocked perfectly, which results in some voicing present during closure (Ladefoged, Johnson 2014, 15). English voiceless plosives fall into the group of consonants with a rather long interval between the release of the articulators and onset of voicing, also called long lag, while voiced phonemes (/b,d,g/) are characterized by short-lag (Abramson and Lisker, 1964).

2.3 Vowel System in Canadian English

Wells (1982) and Boberg (2008) both define CE as a variety of GA with some phonological differences. To a non-native speaker of American or Canadian English, however, these differences may not be recognisible and thus General American and Canadian English may sound virtually identical. [reference? Or are you speculating? Acknowledge or remove]

2.3.1 The low-back merger

One of the most significant features that destinguish Canadian English from either GA or RP is the merger of the low back vowels /ɑ/ and /ɔ/, which may be represented by key words LOT and THOUGHT (Boberg 2008, 150). Labov (1991)calls this Canadian English phenomena, which can also be found in areas like Eastern New England, Western Pennsylvania or Western United States the „Third Dialect". Despite this, it is a feature common all over Canada. Today, basically for every native speaker of Canadian English, pairs such as COT and CAUGHT, STOCK and STALK, DON and DAWN or SOD and SAWED have become homophones (Boberg, 2008, 150). Similar merger occurs also in the Newfoundland area, except the vowel is produced as a low central vowel.

2.3.2 The pre-/r/ merger

Boberg (2008) shows another type of merging in Canadian English, in this case, the merging of some vowel that preceed intervocalic /r/. He offers /eɪ/, /ɛ/ and /æ/ as vowels that are all merged together in lower-mid to upper-mid position. Thus, MARY. MERRY and MARRY all sound the same all around Canada, with the exception of Montreal, where /æ/ remained distinct from the other vowels, making BERRY rhyme with DAIRY, but not with CARRY. (151)

He also adds, that most Canadian speakers have lost the distinction between some of the pairs of mid and back vowels before /r/. As an example, he gives the pair /ɔ/

and /oʊ/, that has dissapeared in most of the varieties of English (FOR and FOUR, HORSE and HOARSE), then vowels /ʌ/ and /ə/, which merge in words such as HER and HURRY As an unexpected merger, Boberg shows that BORROW, SORRY and TOMORROW vowels have merged with BORE, SORE, and MORE, as well as with the vowels in FOREST, HISTORICAL and ORANGE, or FOUR, STORE, and OAR, unlike in other, similar American Dialects. (152)

2.3.3 PRICE and MOUTH raising

When talking about the pronunciation characteristics specific for Canadian English, there is one that the American population considers the most typical for Canadian English speakers (Boberg, 152) It is the phenomenon that occurs when a centering diphthong is followed by a voiceless consonant. CE has special allophones for the diphtongs PRICE and MOUTH, namely [əi] and [ʌu], respectively. Such allophones are used in words such as *pipe, like* or *out, house* and *south.*(Wells, 494). The raising is visible when comparing word pairs such as *out* vs. *loud* or *write* vs. *ride.* To GA listeners the [ʌu] diphtong may sound like a variation of /u/, hence the popular claim that Canadian English speakers say „oot“ and „aboot“ for *out* and *about*. (Wells, 496)

There are, nevertheless, some important facts to be set straight, when talking about the occurence of this Raising. It does not, for example, always occur before a voiceless consonant. In the case of major morpheme boundary, such as in *tie-clip*, the diphthong remaines in agreement with GA as unraised [aɪ]. This does not apply for some speakers, due to the exception to this principle, where the two morphemes are lexically close-bound, as in *high school* [həiskul]. But overall, the Raising is present as long as the voiceless consonant is in the same syllable as the diphtong, for example in *bicycle* or *psycho*, but unraised [aɪ] in *bisexual* or *hypothesis.*

2.3.4 Pattern for loans and foreign words in Canadian English

For loan words, Boberg explains the nativization on loan words containing the letter <a>. Examples used here are words like *falafel, karate, llama, nirvana, pasta,* or *taco.* In most of the variations of English language, the loan words are nativized with either /æ/ or /ɔ:/. In PR, British English tends to use /æ/ in most of the loans, except open syllables. That’s why in RP, *pasta* has /æ/ and *llama* has

/ɔ:/. On the other hand, GA is usually using the vowel /ɔ:/, so both *pasta* and *llama* have /ɔ:/.

Canadian English, however, uses /æ/ in a vast majority of the loan words, even in those, where GA and RP have agreed on /ɔ:/. The only exceptions are final stressed open syllables, such as *bra, faux pas, spa, foie gras,* etc. Older generations of Canadians use /ɔ:/ even in words like *drama, garage* or *Slavic,* although more and more younger Canadians tend to incline to the GA pattern.

2.3.5 Canadian English vs. Czech vowel system

In previous sections, some of the differences between GA and CA were outlined. Because this thesis deals with bilingual speakers of Canadian English and Czech, we must compare the two vowel systems. As described in Šimáčková et al. (2012), Czech vowel inventory consists of ten monophtongs and three diphtongs. Monophtongs consist of five different vowels in two quantities (/i, ɛ aou / and /i:,ɛ:,a:, o:, u:/), or short and long vowels. Czech diphtongs are /au/, /eu/ and /ou/ although /au/ and /eu/ occur only in loanwords or interjunctions. (230)

Podlipský et al. conduct an experiment on 51 monolingual Czech speakers to reveal whether the vowel pair /i i:/ is perceptually distinct based on duration only, or whether vowel quality also works as a cue for listener. The result of the study uncover that for native speakers of Bohemian Czech, the cue for distinguishing /i/ from /i:/ incline to that of vowel quality, rather than its duration, unlike the native speakers of Moravian Czech, who incline to the duration rather than quality as a primary cue for distinguishing the short and long vowel.

The vowel duration part of the experiment in this thesis is longitudal, i.e.. data are gathered over certain amount of time. The aim of the experiment is to find out, whether the time spent in Czech speaking environment causes the participants to pronounce target vowels with duration closer to that of native Czech speaker. In Fig. 1, we can see the mean vowel duration of Czech monophtongs, and the results of experiment gathered in section 5.2 can then be compared to the data from Podlipský et al. (2009)

vowel	n	duration [ms]	SD [ms]	ratio V: / V
ɪ	1,049	53.5	19.9	1.29
i:	691	68.9	36.3	
ɛ	1,595	53.5	16.2	1.72
ɛ:	211	91.8	37.1	
a	1,217	63.1	20.9	1.79
a:	436	113.0	26.3	
o	1,259	51.7	15.4	1.73
o:	5	89.3	17.7	
o͡u	96	102.8	26.4	1.99
u	423	57.3	22.9	1.60
u:	133	91.4	49.5	

Fig. 1 – Mean vowel duration of Czech monophtongs (Podlipský et al. (2009, 134)

The Czech vowel system differs for Bohemian and Moravian speakers, but for the purpose of this study, only the Bohemian variety is used, primarily for the environment where the participants spent the summer is in Bohemia. Subjects' mother originally from east Bohemia, grandmother originally from Hradec Králové and grandfather from Korytná (east Salesia). Both subjects grew up speaking the standart Bohemian Czech.

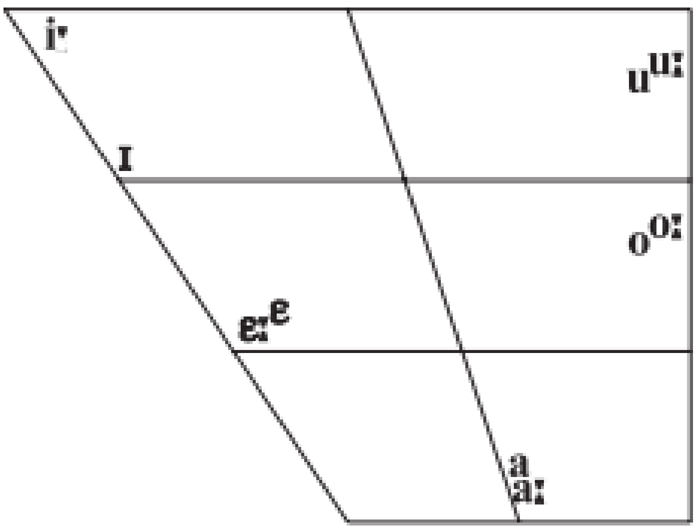

Fig. 2- Vowel systen of Standart Bohemian Czech speaker (Šimáčková, Podlipský and Chládková, 2012, 228)

2.4 Gestural Drift

The phenomenon known as „Gestural Drift“ was used by Michele Sancier and Carol Fowler as perceptually-guided change in speech-production in a bilingual speaker and listeners' perception of these changes in the speaker's productions over time (1997, 421). It is a phenomenon that occurs in one's speech production, specifically after recent experience in a different (in the case of Sancier and Fowler‘s VOT shifting experiment from 1997, the studied languages of the bilingual subject were American English and Brazilian Portugese) language speaking environment. When a speaker is exposed to that language for a certain time period, his or her phonetic properties assimilate closer to those of the L2 environment. (421-422)

In Sancier and Fowler (1997) the subject of the experiments is a 27-years old female, native speaker of Brazilian Portugese. Her in-country residence, or recent experience, is in the United States of America twice a year, so the focus is on the influence of L2 environment on her L1, mainly on the VOT of plosives. The voiceless stops, when word inital, are unaspirated in her native language, and the study measures how the time spent in American English speaking environment changes this aspiration.(422). The subject is late bilingual, as her L2 acquisiton began when she was 15 years old. Conducting a three-part experiment, S&F used the data collected from recording the bilingual subject over time, always after a recent experience in either USA or Brazil (Sancier and Fowler, 1997, 423) The first and second parts were perceptual tests consisting of Brazilian-Portuguese sentences for native GA listeners (experiment 1) and English sentences for native Brazilian-Portuguese listeners (experiment 2) to tell which one sentence from a pair (one being recorded after the subject's stay in the US and the other in Brazil) sounded more foreign to them. In experiment 1, 13 male and female listeners aged 18-35 have selected the sentences uttered after the stay in the US as more accented, proving that the drift has indeed occured and that L1 speaking environment influenced her L2. (425-426) Compared to the results of experiment 2, the success rate for distinguishing the accented sentences correctly is below chance (48%). S&F argue that this may either Experiment results have shown a below chance (48%) success rate in distinguishing the BP sentences played to English listeners. When compared to the performance of the Brazilian listeners, the difference was significant (426-427). To exclude the possibility of the results contradicting the initial hypothesis, the third experiment determines, whether the results from exp.1 and exp.2 occured due to the Gestural Drift present only for the subject's BP and not English, or whether the results were influenced by the perceptual judgement (easier for Brazilian listeners to determine accented/non-accented speech opposed to American listeners differentiating various degrees of Portuguese-accentedness (427). Closer waveform and spectographic examination of BP voiceless stops [p] and [t] opposed to English [p^h] and [t^h] has shown, that the Drift has occured for both languages in similar, predicted direction, despite the English perception test failing (428-431, 433) .

In Chang (2013), a contrast between experienced and inexperienced learners of Korean is examined. Chang focuses on multiple subjects with different backgrounds (born and raised in the USA vs. Korean Americans adopted from Korea early in their life), as well as different proficiencies in Korean Language (Korean-American bilinguals, native GA speakers with Korean as their formal study during or after college, vs. no experience with no prior significant exposure to Korean Language). (2013, 523) All participants were given the same task of English production experiment consisting of 24 monosyllabic English words, which they underwent five times, each time after a week of Korean Language learning programe. His gathered data was used for two separate experiments, one for VOT and F0 measurement and the second, which measured F1 and F2. According to the results of that study, neither experienced nor inexperieced learners showed a significant change in their voiced stops VOT over time. Voiceless stops showed a significant lenghtening for both EL and IL, and thus a phonetic drift (gestural, as called by S&F) has occured and showed an immediate effect on L1 after an intensive exposure to non-familiar L2. (Further familiarization with L2 then eventually reduces the extent of the drift in later stages of L2 proficiency). (2013, 531) He presents two biases as a possible influence in production and perception of spoken language.

Novelty bias (defined as a predisposition for an individual to attend to relatively new information) works as a predisposition for a learner to obtain and recall a these information (520). In other words, an individual is said to store new items into memory when amongst familiar categories, rather than amongst other novel items. (520-521) The second, or recency bias, is defined as temporal order of storing new information. As one could presume, new items presented first are then recalled more easily (in the paper called „primacy effect“), as are the items presented last („recency effect“)As discovered in Goldrick, Runnqvist and Costa (2014), for a voicing language like Spanish, no change in VOT was observed in Spanish after immediate switch from English, but there was a less English-like VOT production in voiceless initial stops in English words after the immediate switch from Spanish.(1033-1034) Similar result has been reached in Toblin, Nam and Fowler (2017), where the hypothesised drift pattern was observed only among the participants‘ L2 English VOTs, not among their L1 Spanish VOTs. (57) This contrasts Chang (2012), where he reached conclusion that „an abundance of evidence from bilingual studies has shown that L1 production can be significantly affected by L2 experience“ (2012, 252). It is, however, later disproved in Chang (2013), where he acknowledges that with increasing proficiency of L2, the impact on the phonetic drift decreases. (see section 2.4)

2.5 Bilingual phonetic system

In this section, I will talk about the L1 and L2 phonetic systems and their coexistence in bilinguals brain. I will outline possible structures in which the systems are organised and connected and then I will discuss some topics relevant to bilingual subjects, namely code-switching and interference... In section 2.6 I will also outline the topic of Speech Learning Model (SLM) and what its‘ role is in terms of bilingual speaker. Flege (2003) talks about age, or the effects, that age might have on learner’s L2 production. The system in which L1 and L2 are organised in bilinguals brain... Escudero (2007) gives several possible ways in which L1 and L2 might coexist and connect. Each sound category is stored as knowledge and depending on the degree of interconnectedness of the individual L1 and L2 subsystems it idetermines where is the given speech category stored. Cook (2002) labels the individual degrees of coexistance *separated*, where the individual systems are completely isolated from one another, then *connected,* with an overlap into one another, and then *mixed* (either merged, implying no language differentiation, or integrated, which implies a single combined system), where the L1 and L2 are viewed as a single system. (Escudero, 2007; Cook, 2002) For example, the English aspirated /p ʰ / vs. the Czech unaspirated /p/ might not be distinguished by a monolingual L2 learner of English, when a bilingual speaker might. Brown and Copple, (2018) conducted a VOT experiment on monolingual speakers and early bilinguals of English and Spanish to find out how the phonetic features are organised for monolingual and bilingual speakers. (54) As VOT is said to serve usually as primary cue in production of stop consonants, Antoniou et al. (2010) discovered that early bilinguals display category representation in both languages nearly on the identical level of monolinguals of each language, whereas L2 dominant bilinguals may even show loss of L1 VOT patterns as L1 proficiency rises (Holm and Dodd,1999; Flege, 2003) and Hambly et al. (2013) argue that the higher the age during first exposure to L2, the less effective will the L1 acquisiton mechanism operate. Holm and Dodd also discovered that the phonological developement and error pattern of bilingual children of English and Cantonese was unique for each language and different from monolingual of each language, suggesting not only the influence of L1 and L2 on one another, but also the fact that they use separate phonological systems.(350) Scovel (1998) also adds to this topic that late bilinguals show strong foreign accent, once surpassing certain age.

The second possible explanation for the influence on one's L2 subsystem is merely the fact that late bilinguals usually recive L2 input that is not as satisfactory as the input early bilinguals are exposed to. When early bilinguals spend majority of their time in an L2 speaking environment (primary school, hobbies and other everyday activities), then they are likely to become L2 dominant, while a late bilingual with the same ratio of L1-L2 exposure will not tend to the same result. (Flege, 2003)

The third possible influence given is said to be language interaction. In theory, if one was to analyse native-like L2 speech without any interference, it could be hypothesised that a bilingual can establish independent L1 and L2 phonetic subsystems without influencing one another. (468-469) This, however, contradicts with in Wei (2000), where he presents a theory about bilingual's phonetic system development and age influence on L2 acquisition. He talkes about unitary-language system:

> Language mixing during the early stages of bilingual development has been interpreted in general terms as evidence of a unitary-language system with undifferentiated phonological, lexical and syntactic subsystems (...)Even rules that are specific to each language are initially stored in common storage and subsequently tagged as appropriate for a particular language through a process of differentiation. (Wei, 2000;309)

Piske et al. (2001) talk about the Critical Period, or the stage in one's Second Language Acquisition, after which the acquisition is no longer possible (196). If we apply this hypothesis on the subjects, who are early bilinguals, but their language proficiency in L2 has decreased rapidly before the critical period, they might never be able to reach equal L1 and L2 proficiency again. Piske then gives several factors that may influence the degree of a speaker's foreigh accent in L2, namely language use, gender or lenght of residence. According to Asher and Garcia (1969), gender bears a great difference in the age of learning, when the learner's age is higher than six, with female participants scoring higher than male participants. The significance of gender also decreases with the lenght of residence increases. On the other hand, there are some linguists, who have found lenght of residence a non-significant factor in gaining L2 proficiency (Moyer, 1999; Johnson and Newport, 1989). Again, subjects of this thesis have had very limited exposure to L2, which resulted in strong English dominance.

2.5.1 Code-switching and Interference

Talking about bilingual phonetic/phonological system, we it is also important to take into consideration code-switching, or code-mixing, as the subjects of this particular thesis often switch between the languages during spontaneous conversation. In chapter six of The Handbook of Bilingualism by Bhatia and Ritchie, Pieter Muysken talks about code-mixing as language contact from the morpho-syntactical and lexical fields. He also adds that code-mixing doesn't nesscesarilly suggest that it is a result of an impetuous production, but rather a result of a pattern set in the bilingual's language system (2006, 149). A rather simple explanation for bilinguals‘ code-mixing is that bilingual speakers use code-mixing when they lack the lexical material from either language and so they borrow items from the other language, whichcan be shown on an example 1:

(1) I'll go schovat.

I	will	go	schovat
1SG	be-FUT	go	hide

I will go hide.

Here we can see code-switching between the English lexical material and morpho-syntactical system „I'll go hide“ and Czech system „Půjdu se schovat“.

The second type of language contact common for bilingual speakers is interference. The difference between code-mixing and interference is that during code-mixing, both morpho-syntactical structures and lexical material is present from both languages (Bhatia and Ritchie, 2006). However, interference is a mutual influence between bilinguals‘ two languages only in the morpho-syntactical system, but lexical material only from one of the languages is present (147). Again, it can be demonstrated on an example 2:

(2) Já budu zpátky.

I	be-FUT	back

I will be back.

Bhatia and Richie (2006) argue that interference in terms of research is rather difficult to study, because it can be taken as more challenging to analyse and measure. He supports this claim by saying that it is simply easier to spot lexical borrowings and code mixing from one language to another, than it is to go through individual morphemes to discover patterns of morpho-syntactical interference.

Antoniou et al. (2011) argues that interference between L1 and L2 may be a result of one of four factors. Either direct L1-influence on L2, L1 and L2 mutual interface, direct L2 influence on L1 (he uses Flege, MacKay and Piske's study from 2002 as an example of Italian and English bilinguals, who have been exposed to L2 intensively for extensive period of time, which has resulted in the dissapearence of any foreign accent, and in L2 becoming the dominant language, influencing their L1) and no mutual influence whatsoever as the fourth possible factor.

In Obler et.al. (1987; 2000), a connection between the coexistence and contact of two languages and cerebral lateralization, e.g. the usage of hemispheres, is presented. The study dealt with a question whether, depending on the age (early or late bilingual) and manner (natural or formal) of L2 learning, language as such will be more left-hemisphere oriented for monolingual or bilingual speaker (41,43-44). Sussman et.al. (1982) study of interference in tapping rate in fluent bilinguals simultaneous speech reached to a conclusion, that early bilinguals showed a strong left-hemisphere preeminence over those, who acquired L2 later in their life, as these subjects showed a more right-hemisphere language processing. (138) That may be, perhaps, explained by stating that a late onset acquisition requires a somewhat more logical and systematical approach, while for children who are bilingual from birth, the exposure to L2 comes in an informal, more subconscious manner, unlike late bilinguals, who usually attend classes and courses to gain proficiency in L2. This is complemented by one of Muysken‘s (2006) conditions, under which complex mixing is possible:

> (2) Most, and certainly all complex, code mixing has been recorded in informal in-group conversations. (156)

In given environment, one is prone to use more code-mixing, in a smaller group of familiar people with low level of formality (e.g. family celebration), than among random unknown people or outsiders and certain expected level of formality (e.g. presentation in class) (156).

Another important factor in L2 acquisition is the environment in which one acquires their proficiency in L2. For this topic, Obler (2000) gives as an example a study by Gordon(1980), which gathered data from speakers of English and Hebrew. Results of this study showed that a native Hebrew student with onset acquisition of L2 during adolescence as a foreign language in Israel would do considerably better in both Hebrew and English than native Americans whose L2 acquisition began during same age, except in Israel. (357)

Balukas and Koops (2015) add to the domain of code-switching that the similarities between two languages are expected to come either as an overall result of long-term contact or as a specific result of code-switching in long-term, or after immediate switch, presumably ocurring at all levels of the bilingual language system. (424)

2.6 Speech Learning Model

Flege‘s (1995; 2002; 2003)Speech Learning Model (SLM) is defined as two language phonetic systems both existing in a common phonetic space Therefore, an inevitable influence on one another is expected. Acording to his study from 2003, According to Speech Learning Model, adults learing L2 retain the capacity that infants and young children have, when acquiring their L1 (Flege, 1995; Escudro 2007). Flege then gives two different mechanisms:

> Category assimilation is thought to operate when a new category fails to be established an L2 speech sound despite audible differences between it and the closest L1 speech sound. (Flege, Schirru and MacKay 2003, 469)

The second mechanism in this paper Flege calls phonetic category dissimilation, which

> is thought to operate when a new category has been established for an L2 speech sound. It will cause a newly established L2 category and the nearest L1 speech category to shift away from one another in phonetic space. (Flege, Schirru and MacKay 2003, 470)

Consequentialy, that means, whenever a new speech category is created a bilinguals brain, it creates different L1 and L2 categories along with a percetual difference in both L1 and L2 from that of native speaker. (Flege 2002; 2003; Escudero, 2007) According to this theory, the greater phonetic differences between L1 and L2 sounds, the higher the rate for L2 learners to succesfully distinct and store those two items, which results in greater progress in their production and/or perception. (Aoyama et al., 2004)

The mechanisms defined above suggest, that when a new category, in the case of this study, let’s hypothesise that this new category will be prevoiced /b/, is presented to a L2 speaker and fails to fall into an already existing category, specifically English /b/, which is in fact short lag voiceless stop, a new category will form. A similar prediction can be made about the aspirating contrast between

English [p ^{h}] and Czech unaspirated [p], which might be considered, for an inexperienced learner of either language, as its‘ closest allophonic equivalent. However, the language combination of voicing (one that has negative VOT, or prevoicing) and Czech language versus aspirating
(short positive VOT) English language presents an interesting advantage in the discussion of Speech Learning Model.

3 Predictions and Hypotheses

As previously discussed in section 0, Sancier and Fowler (1997) based their phonetic study on a bilingual speaker of English and Brazilian Portugese. Based on the results of this study, it can be predicted, that after a two month long period in purely Czech speaking environment, the subjects‘ VOT will shift closer to that of native Czech speaker, e.g. will be shorter in voiceless stop inital words and for the voiced counterparts, prevoicing will appear. Specifically Czech voiceless stops (p,t,k) will become less aspirated, similarly to the findings of Sancier and Fowler (1997, 2017), in which they also compare aspirating English with non-aspirating language (Brazilian Portugese). Considering the L1 and L2 balance of the subjects (English being dominant), the vowel duration experiment outcome could be, if at all, significant for the Czech part. It might be considered unlikely for the subjects to undergo any radical changes in their dominant language. However, depending on how their L1 and L2 phonological systems are connected (see sections 2.4 and 2.5), the results might be different for both languages. For the second part of this study, I will record and measure both participants pronouncing words with various vowels (long and short in Czech language, after voiced and voiceless coda in English) and then focus on their duration across two sessions, analysing which factors, or interaction between them, have influenced the shortening or lenghtening of given vowels the most.

Hypothesis 1: Both subjects will go through gestural drift, resulting in shortening their VOT in Czech voiceless stop initial words, with less or none aspiration after the recent experience, and preserving their long-lag aspirated VOT in English with zero to minimal changes. Additionally, both subject will successfully use prevoicing in Czech voiced stop initial words after the residence. No major changes in English voiced stop initial words are expected.

Hypothesis 2: Vowel duration for both subjects will become shorter for Czech words containing short vowel, and longer for Czech words containing long vowel. The duration of English vowels is not expected to change significantly, but the mean duration of vowels are expected to change slightly towards those of Czech vowels.

4 Acoustic Experiment

4.1 Methodology

Both subjects were familiarized with the Czech words used in this experiment without directly telling them „this is how you pronounce this word". It was done to prevent unnescessary pronounciation errors and to remind the subject of some of the less frequent words used for this experiment, such as BŮČEK, DÉMON or DIVOCH. All words were used in questions and commands that were asked them during one day before the first recording session. As an example, some of the words used for measuring Czech VOT were PIVO, BALÓN, TOPENÍ or BATOH. Questions and commands were

(1) Emily, podáš mi BATOH? Je u TOPENÍ.
(*Emily, will you pass me the bag? It's by the heating.)*

(2) Kate, zeptej se dědy, jestli si dá PIVO.
(*Kate, ask granpa, whether he would like a beer.)*

(3) Holky, kdo z vás nechal ten BALÓN na zahradě?
(*Girls, which one of you left the ball in the garden?)*

All the other words were included in similar improvised dialogue throughout the day, so both subjects would have the chance to hear the words without them knowing it.

4.1.1 Participants

The experiment had two female bilingual participants, sisters, aged 13 and 16, with English language being the dominant one. Mother is netive Czech, late bilingual, with average to moderate L2 proficiency prior to meeting her husband, father of the subjects, who is native Canadian. Their exposure to L2 (Czech) is limited, being very high during their grandparents‘ visit in Canada every Febuary for three weeks, and their visit in the Czech Republic every summer for two months. Besides these two occasions, the exposure to Czech language is very limited. Both were spoken to in Czech very intensivly during the first five to six years of their life, mostly by Czech-native mother, as well as their grandparents during every summer visit in Czech republic, that lasted for three months until 2013. Since then, both subjets experienced a rapid decreasing of L2 performance and usage. Communication between them and their mother is mostly in English, school environment is purely English-speaking.

4.1.2 Stimuli

The participants were shown four lists of words, (VOT English, VOT Czechvowel duration English and vowel duration Czech). Each list consisted of 20-50 words in both Czech and English. Participants were familiarisedwith the Czech words prior to the first recording session.. The lists focusing on VOT consisted of monosyllabic and two-syllabic stop initial words, chosen so every plosive was covered (/p/, /t/, /k/, /b/, /d/ and /g/) and also that every of the plosive was followed by a number of different vowels. for Czech VOT, /tj/ and /dj/ were also examined. The word lists focusing on vowel duration consisted of words covering all czech monophtongs (/i, ɛ, a, o, u /)for both long and short variation of that vowel. For English vowels, (i, ɪ, ɛ, æ, ɑ , ɒ, ɔ, ʊ and u).

4.1.3 Procedure

The words appeared on a computer screen in controled output (2 second intervals between English words, 5 seconds between Czech words.) and participants were asked to read them aloud. In case of pronounciation error or a mistake, participants were gestured and asked to repeat the word shown on the screen again, until pronounciation was correct. Total of sixteen recordings was made (two subjects, four word lists each over two separate sessions) and a total result of 685 samples was gathered.

Out of these samples,10 did not meet the requirements, either due to pronounciation error, external noise interference or device malfunction. Total of 675one-word recordings were analysed and measured in Praat software platform. Each word was recorded twice (once during each session) and then compared to one another.

VOT was measured for each word from the release burst interval to the first periodic sine wave suggesting the onset of a vowel. Vowel duration for each recorded item was measured by selecting the first zero crossing the beginning of periodical sine waves with clearly visible formants suggesting the onset of target vowel,(Machač and Skarnitzl, 2009) and the end of the near absence of formant structure and the periodicity of waveform waves. (2009, 30). In case of unclear boundary between individual speech sounds, the boundary was placed in the midpoint of the transition (2009, 80).

5 Results and discussion

All used samples were analysed and anotated using the software Praat and then submited to STATISTICA software, using the analysis of variance, or ANOVA. For VOT experiment, following criteria were used as variables: Language (Czech or English), Session (1 or 2), Underlying Voicing (Voiced or Voiceless). For vowel duration experiment, following criteria were used as variables: Vowel Type (lax or tense), Session (1 or 2), Voicing Coda (voiced or voiceless). Results from each participants will be stated separately.

5.1 VOT experiment

	Observed vs. Expected Frequencies (Emily) Chi-Square = 6,138298 df = 1 p = ,013229			
Session	Observed Prevoicing	Expected Prevoicing	O – E	(O-E)** /E
S 1	6,00000	11,75000	-5,75000	2,813830
S 2	18,00000	11,75000	6,25000	3,324468
Sum	24,00000	23,50000	0,50000	6,138298

Table 1 – Number of present Prevoicing for Subject 1 for English over Sessions

In Volín (2007,127) , chi square is defined as a method, that takes the actual number of items, makes an average of those items over both cases and then presumes an expected result. The difference between these result is then squared and compared with the expected frequency. This will grant us a support that can be compared with the actual results of the experiment and thus can help us with either confirming or disproving our hypotheses. The frequency of prevoicing occurence for each speaker and Chi square was on the number of present prevoicings per Language (Cz, En) per Time (S1, S2) per Speaker. In _ we can see the prevoicing present for Subject 1, specifically 6 cases of prevoicing during session 1 and 18 during session 2 for English voiced stop initial words. Chi square test for this Subject has showed significance (Chi-Square = 6,138298 df = 1 p = ,013229). Similar, marginally significant results (Chi-Square = 3,222222 df = 1 p = ,072646) were present for Subject 2 English language prevoicing (4 cases of prevoicing during Session 1 and 11 during Session 2). However, in contrast to that, neither of the subjects' chi square tests displayed significant results for Czech prevoicing (Chi-Square = 1,074468 df = 1 p = ,299939 for Subject 1, Chi-Square = 1,888889 df = 1 p = ,169328 for Subject 2) despite the overall presence of prevoicing observed being higher during Session 2.

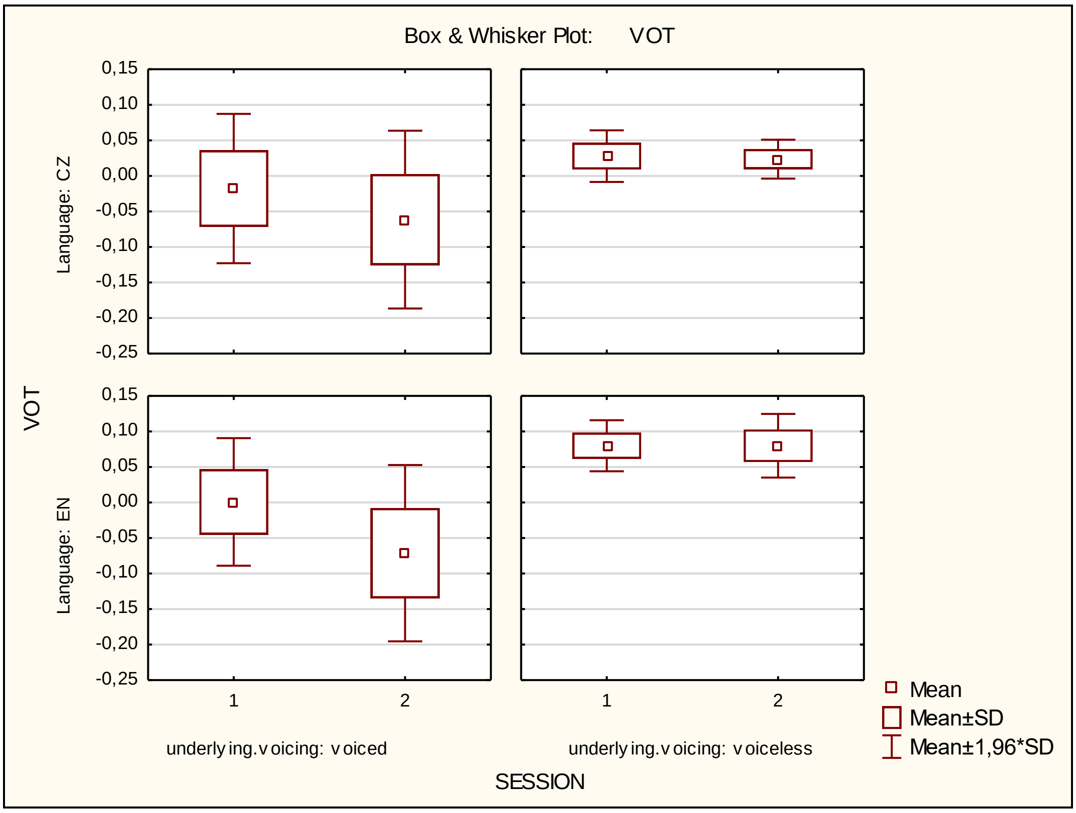

Fig. 3 – Box and Whiskers Subject 1

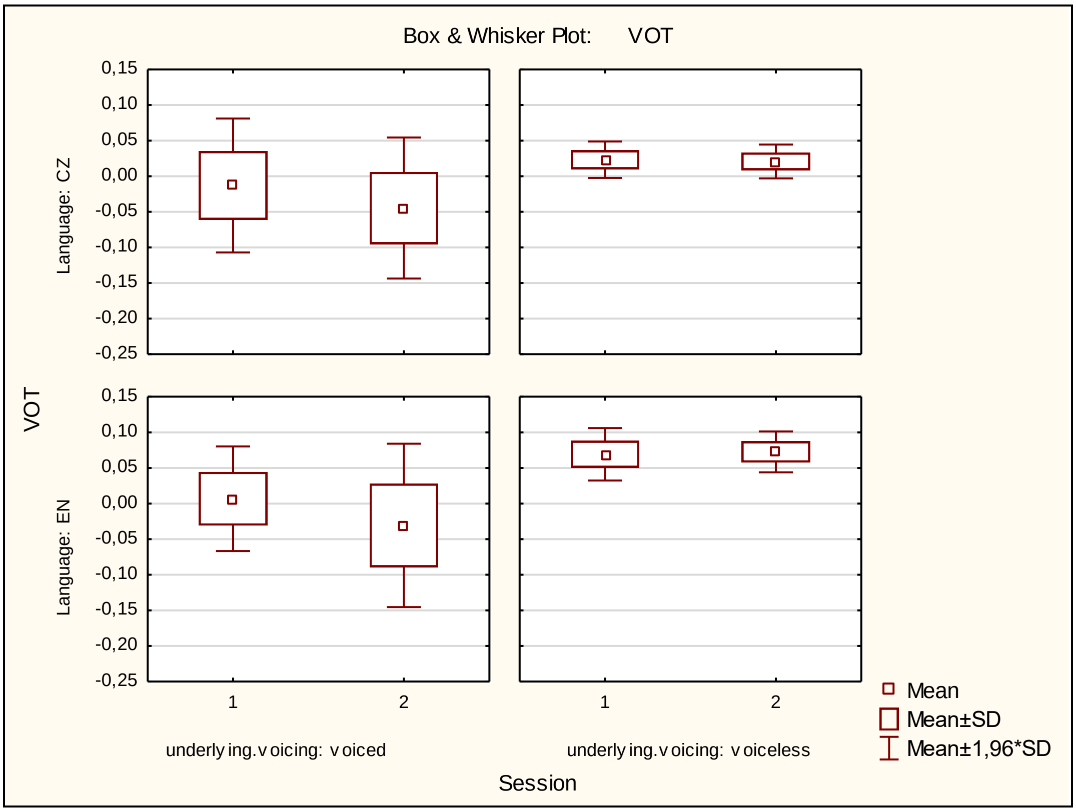

Fig. 4 – Box and Whiskers Subject 2

For each speaker the measured VOT values were submited to a factorial ANOVA with Language (Czech, English), Session (1, 2) and Underlying Voicing (Voiced, Voiceless) as the indipendent variables, or factors. The ANOVA tested for the main effects of each factor, as well as their interactions.

5.1.1 Part one: VOT subject 1

Subject 1 EM	F[1,188]	p
Language	24,2	,000*
Session	25,3	,000*
underlying.voicing	228,8	,000*
Language*Session	1	0,313
Language*underlying.voicing	17,4	,000*
Session*underlying.voicing	21,9	,000*
Language*Session*underlying.voicing	1,9	0,171

Table 2 – ANOVA Results of Subject 1, VOT

The results showed that Language, as expected, had a significant main effect (F(1, 188)=24,201, p=,00000). Underlying Voicing also, as expected, had a significant effect (F(1, 188)=228,76, p=0,0000). Importantly, the analysis also revealed a significant main effect of Session in the expected direction(F(1, 188)=25,303, p=,00000). Session 1 VOT were more positive, or longer, with mean value 22,7ms, and for Session 2, where the overall mean VOT was -7,3ms. The analysis also revealed that there were no significant reaction between Language and Session (F(1, 188)=1,0252, p=,31258).

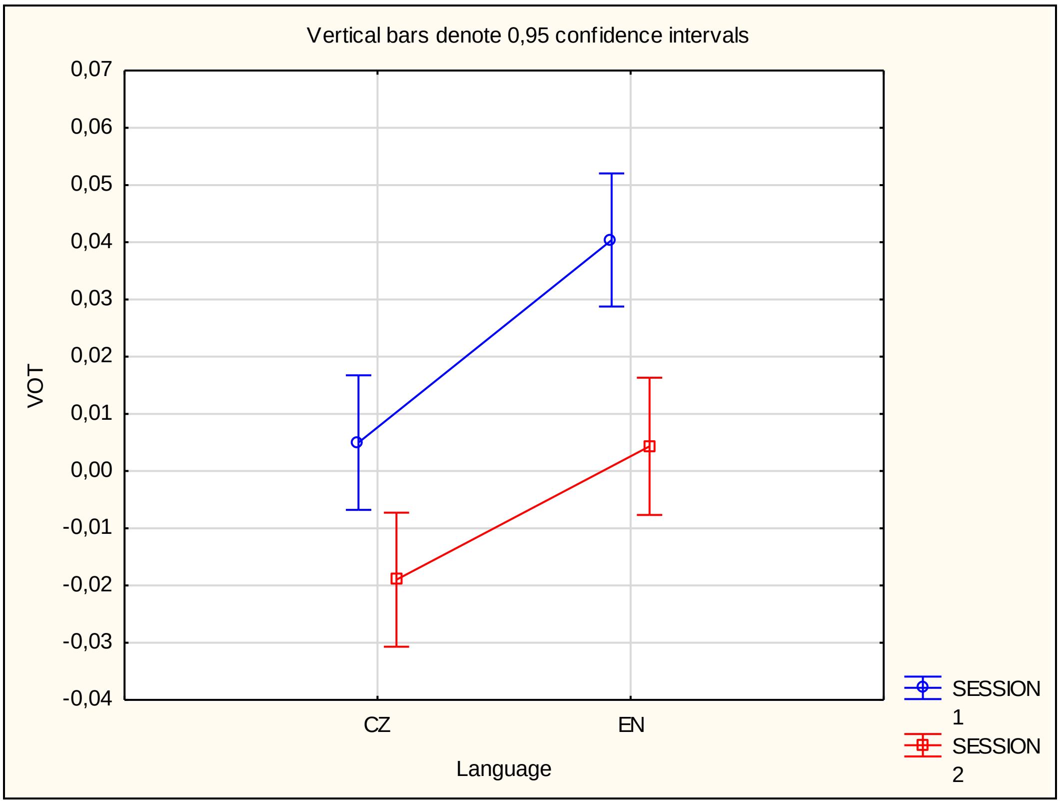

Fig. 5 – Interaction between Language and Session

Next, there was a significant interaction between Session and Underlying Voicing (F(1, 188)=21,870, p=,00001). For voiceless consonants, whether Czech or English, there has been no change between sessions, but again, for voiced consonants, there was a lenghtening of prevoicing for both languages from session 1 to session 2. There was also a interaction between Language and Underlying voicing (F(1, 188)=17,396, p=,00005). When VOTs were pooled over session 1 and 2, there was a significant difference between Czech and English for voiceless, but not for voiced stops. The triple interaction between Language, Session and Underlying Voicing was not significant (F(1, 188)=1,8877, p=,17110). As shown by a posthog tukey test, there was no significant difference between voiceless stops between sessions for either Czech or English, but there was a significant difference between sessions for voiced stops for both Czech and English with an increase in the duration of prevoicing, i.e. a higher negative VOT value.

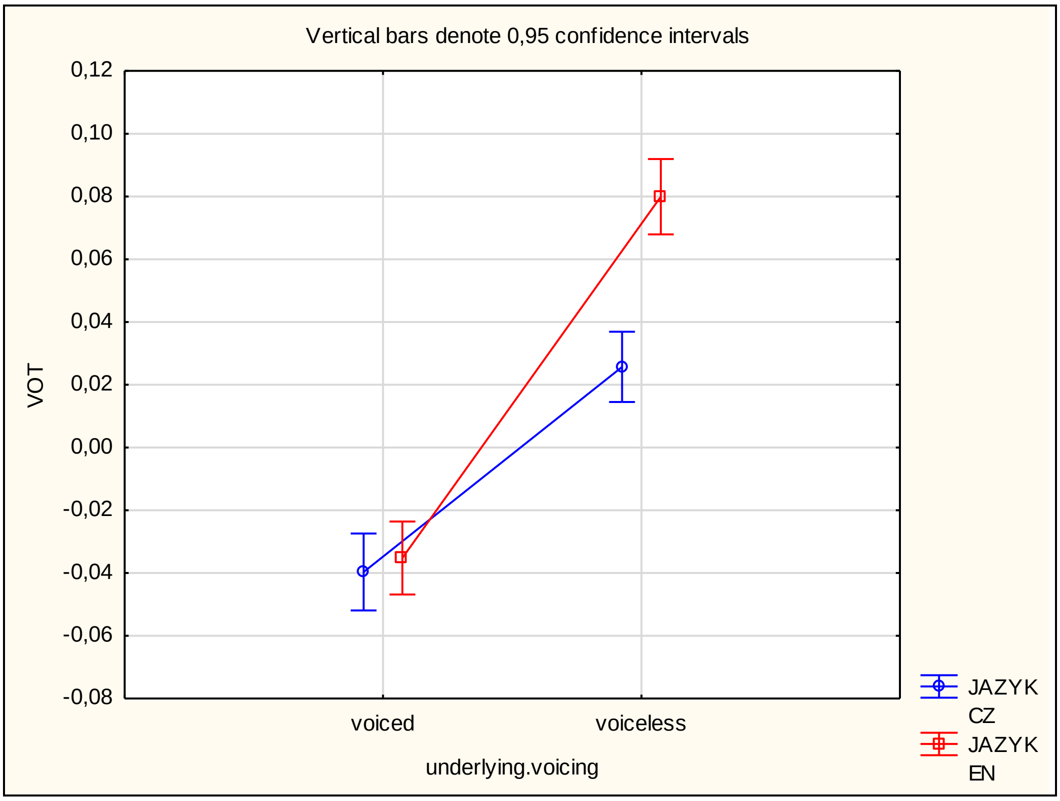

Fig. 6– Interaction between Language and Underlying Voicing

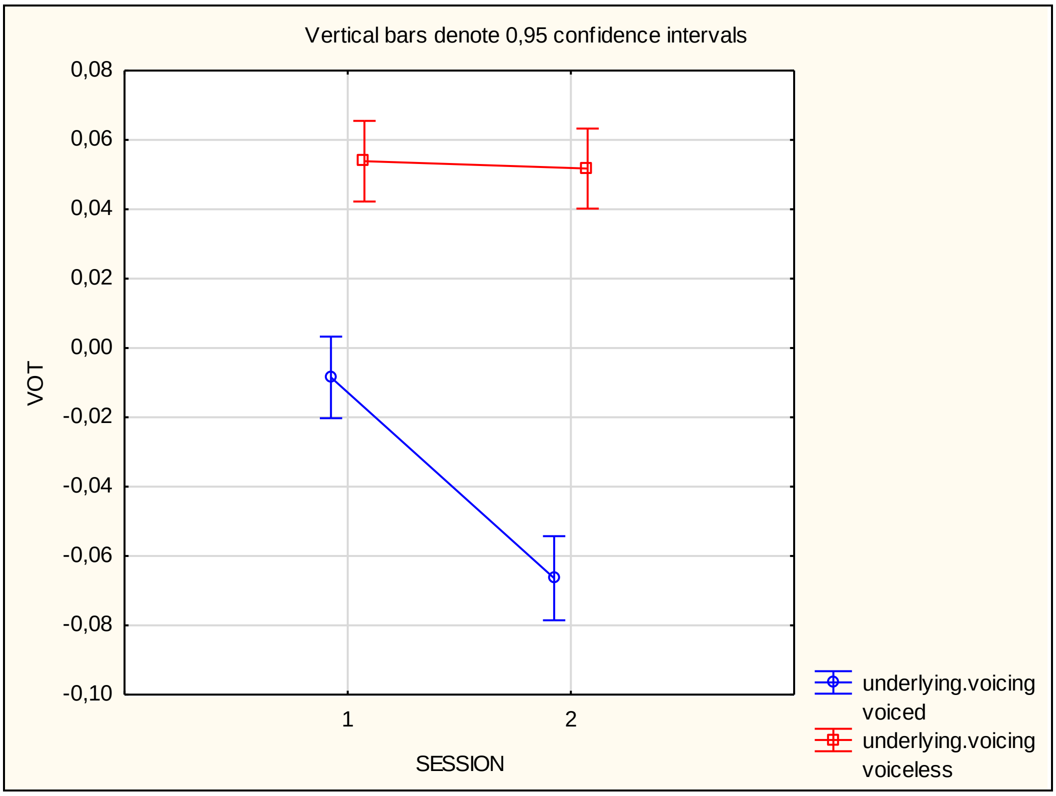

Fig. 7– Interaction between Session and Underlying Voicing

5.1.2 Part two: VOT subject 2

Subject 2 KM	F	p
Language	40,7	,000*
Session	10,99	,001*
underlying.voicing	168,9	,000*
Language*Session	0	1
Language*underlying.voicing	9,7	,002*
Session*underlying.voicing	11,7	,001*
Language*Session*underlying.voicing	0,3	0,576

Table 3 – ANOVA Results of Subject 2, VOT

The results show, that Language, as expected, have a significant main effect (F(1, 188)=40,670, p=,00000). Moreover, both Session (F(1, 188)=10,993, p=,00110) and Underying Voicing (F(1, 188)=168,94, p=0,0000) also have significant effect, as the analysis has shown. The effect direction is similar to that of subject 1, with only minimal differences. Additionaly, no significant interaction was discovered when analysing Language over Session 1 and 2 (F(1, 188)=0,0000, p=1,0000). Both Czech and English mean VOTs have moved identically, for Czech Language from S1 mean VOT 5,2ms to S2 mean VOT -11,9ms, making the session 2 mean VOT move across the zero position and into the negative VOT, i.e. prevoiced. English mean VOT in S1 38ms shortens, specifically to 20,9ms during Session 2.

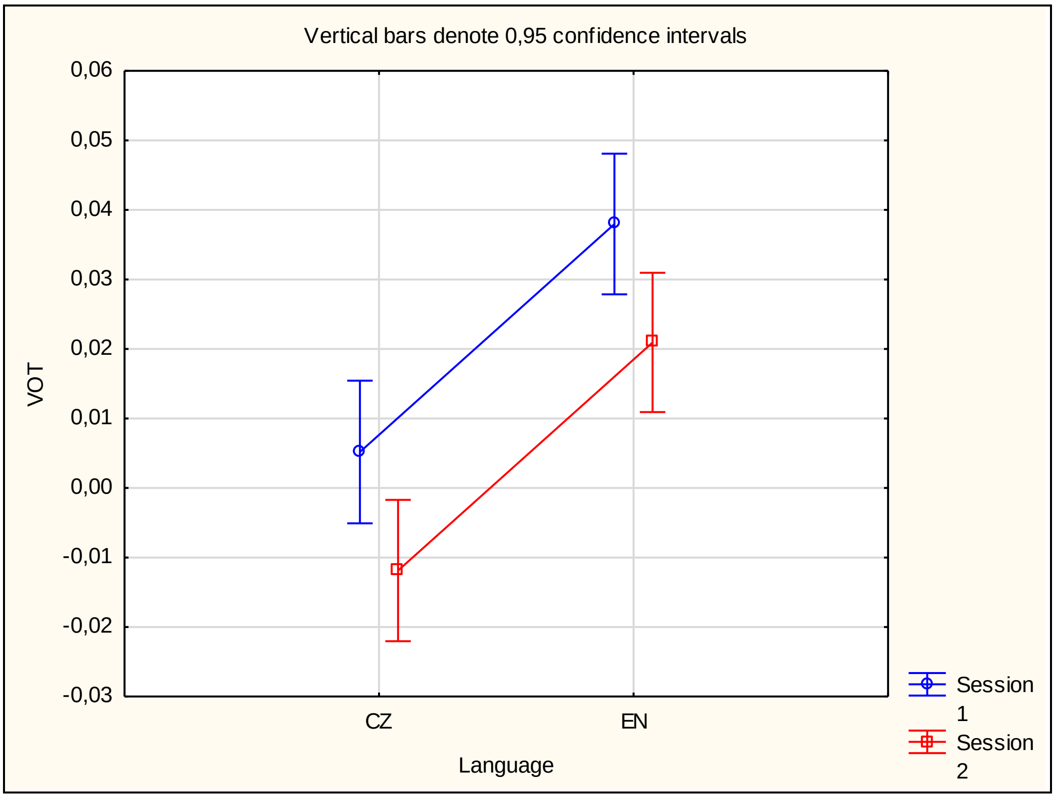

Fig. 8– Interaction between Language and Session

Next, a significant interaction between Session and Underlying Voicing was discovered (F(1, 188)=11,672, p=,00078). For voiceless stops, the mean VOT remaines virtually unchanged over sessions (>0,1ms), whereas their voiced counterpart VOTs, both Czech and English, have lenghtened from session 1 to session 2. Triple interaction between Language, Session and Underlying Voicing has shown no significant effect (F(1, 188)=,31359, p=,57615), although futher examination using Tukey HSD test and LSD test have shown, that there in fact were significant effects between Language, Session and Underlying Voicing for Voiceless Czech stops (with Voiced Czech narrowly exceeding significance) using the HSD Tukey test, and significant difference for both Voiced and Voiceless Czech consonants using the Least Significant Difference (LSD) test.

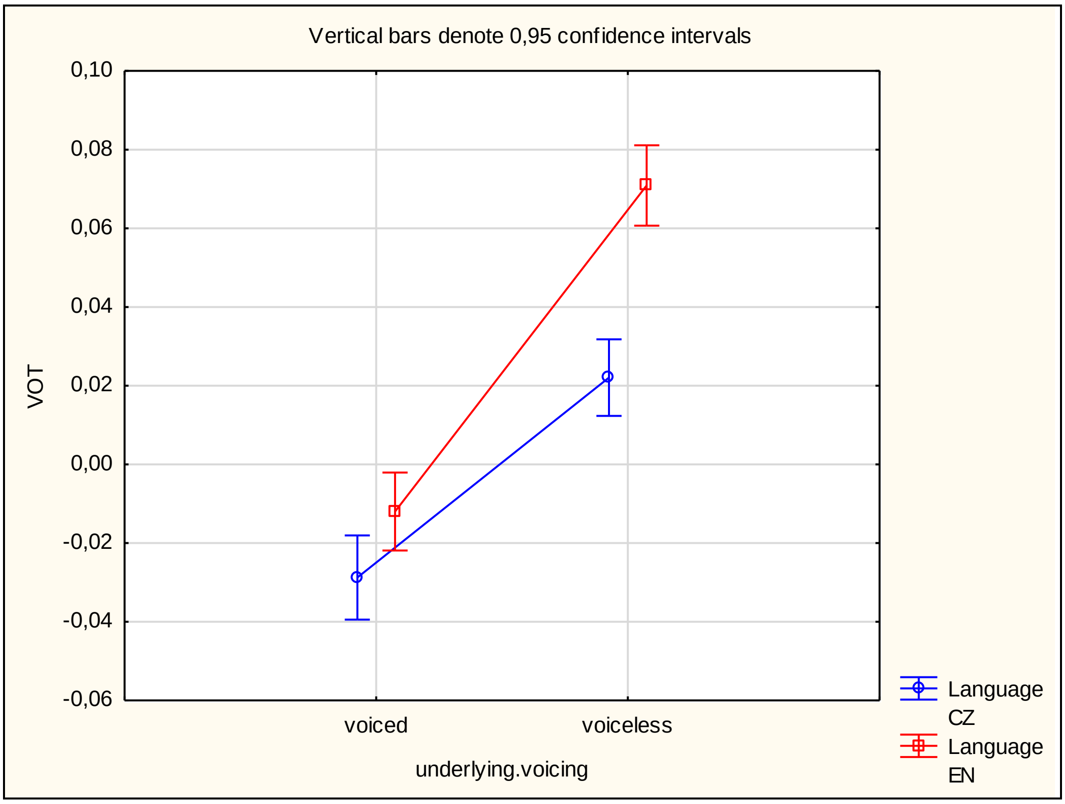

Fig. 9 – Interaction between Language and Underlying Voicing

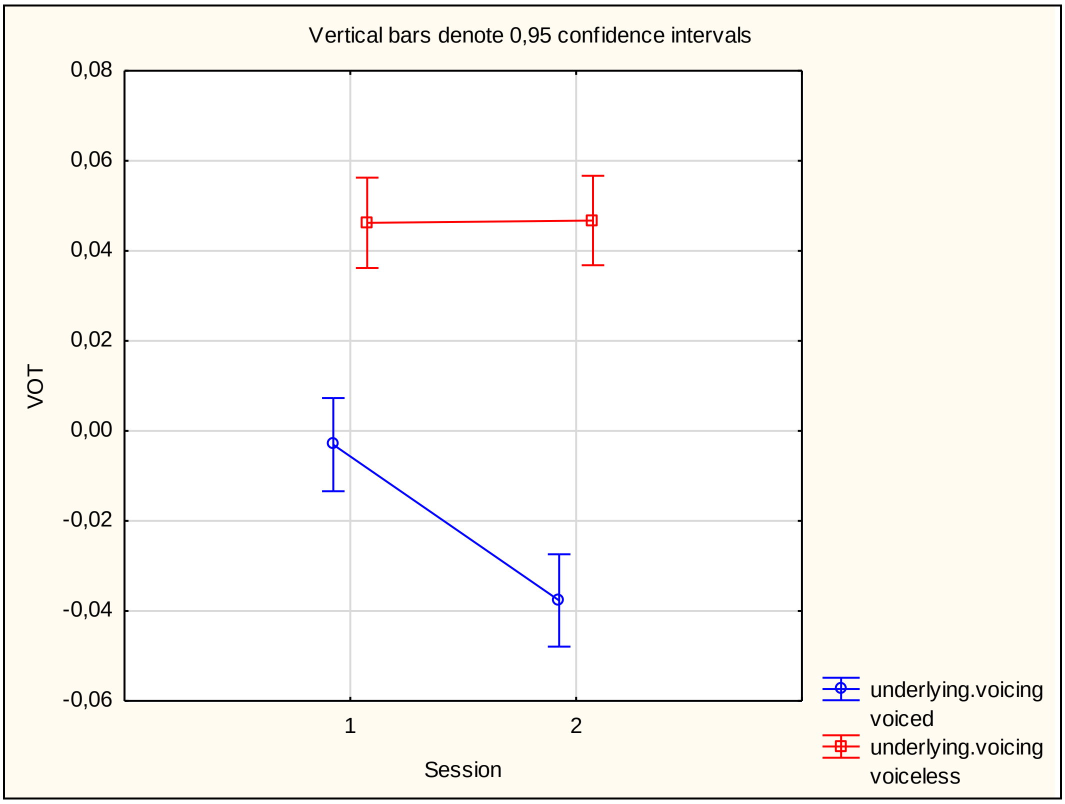

Fig. 10 – Interaction between Session and Underlying Voicing

5.1.3 Discussion: VOT measurements

Before the results will be compared with the initial hypothesis, it is important to say, that the phonetic changes developed are close to being identical for both subjects, which is understanable, given the circumstances of the experiment (same environment, same time spent in Czech speaking community, but also the fact that they are sisters). which suggests that her treatment of both Czech and English were affected by the time spent in the Czech speaking

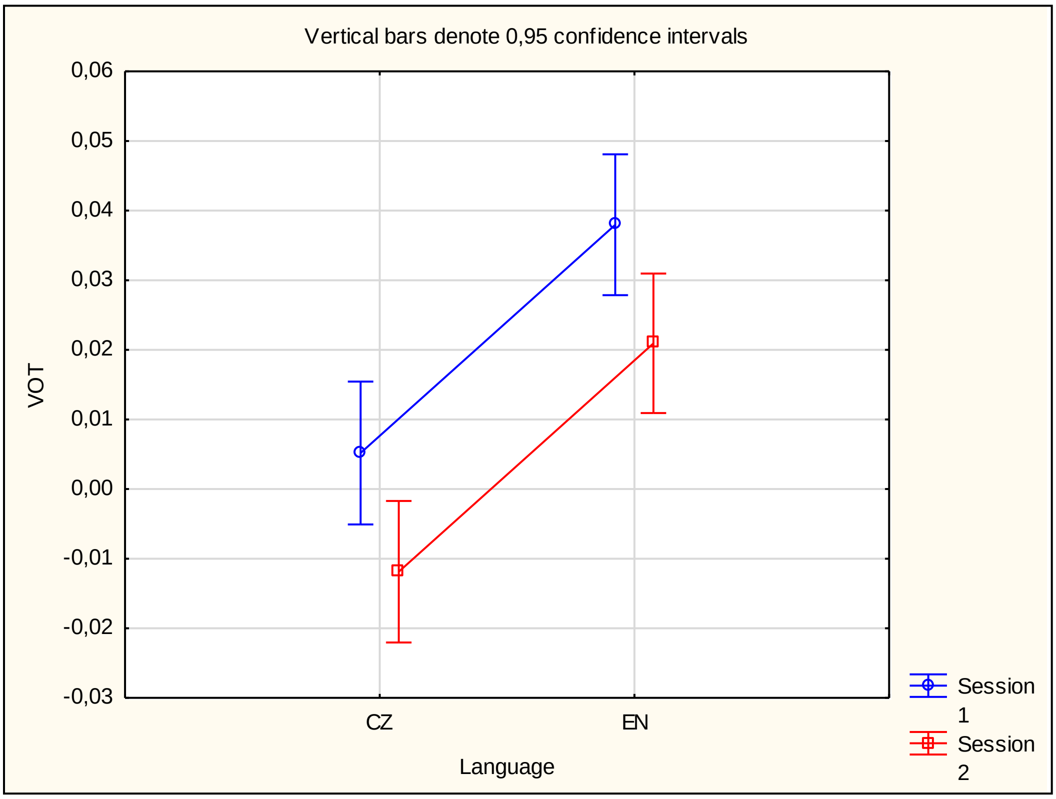

Fig. 11 - Subject

environment in a similar way. When we consider the interaction between Language and Session (Fig. 5 and

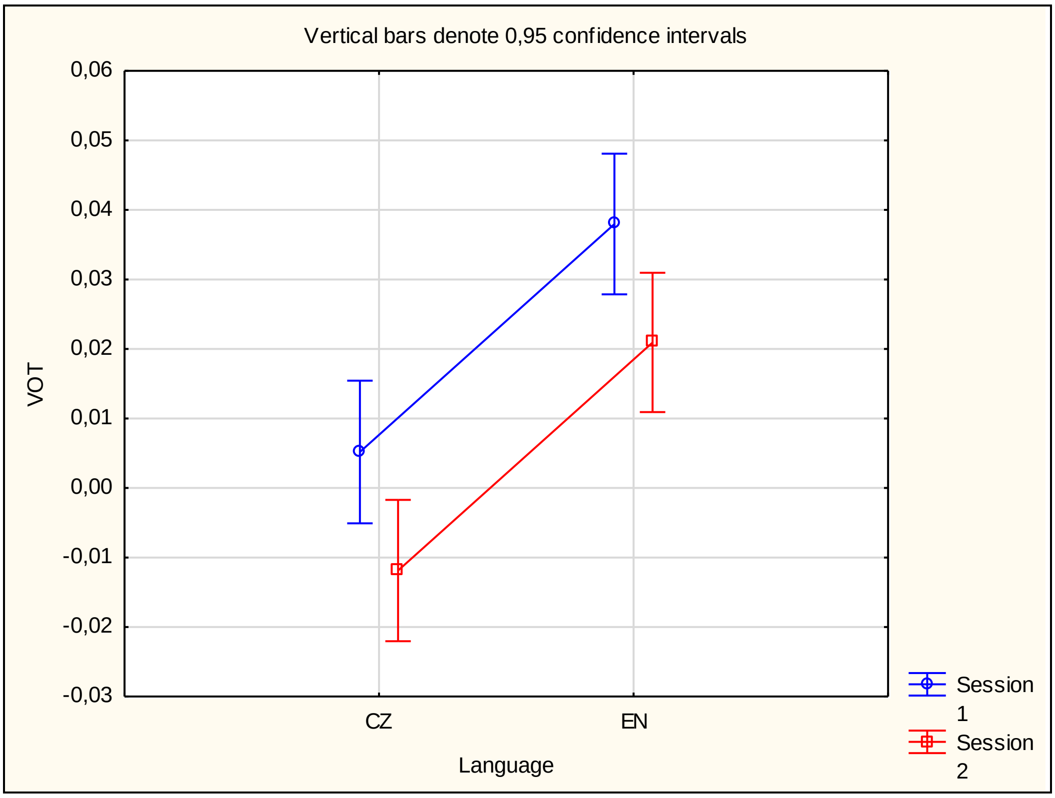

Fig. **8**), we can clearly see, that the change in both languages over Sessions is merely identical. As discussed in the section 2.5, the phonetic subsystems of bilinguals L1 and L2 coexist in one shared phonetic space, and this can be viewed as a proof of this. We can compare the overall phonetic changes between both subjects on

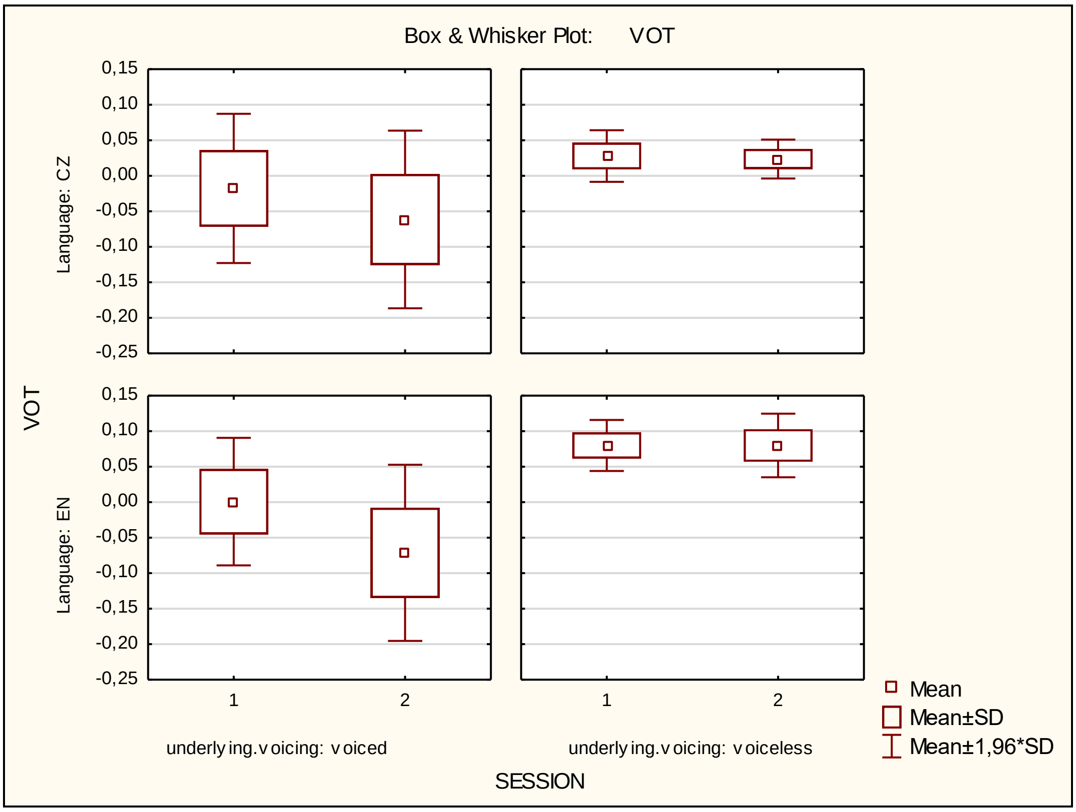

Fig. **3** and

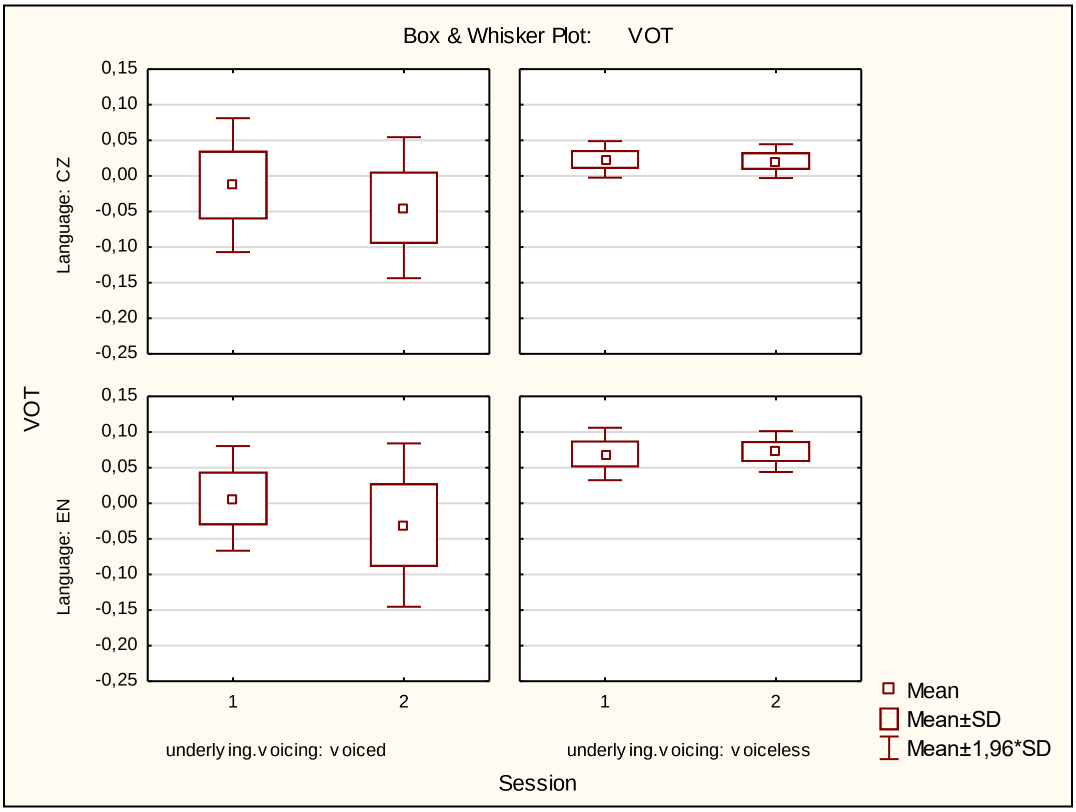

Fig. **4**.. Here, it is clearly visible, that the mean VOT of both subjects was in similar position during session 1, and the effect of the recent experience has changed the VOT in united direction. There is a slightly bigger progress made by

Subject 1, especially in the Voiced consonants across both languages. The progress made in prevoicing is observable in the chi square test (see Table 1). For both subjects, Session 1 results were below the expected amount, whereas Session 2 results have exceeded the expected amount. For Czech language, the negative VOT has occured more times for both participants, supporting the initial hypothesis, that the acquisition of prevoicing in L2 will be succesfull for both subjects. Surprisingly, the English voiced consonants are prevoiced more frequently as well, which could be explained by the Czech language being a voicing language, and the heavy exposure to this type of language has temporarily overruled the English phonetic features of voiced initial stop being pronouced as its‘ devoiced allophone. As mentioned before, the VOTs of voiceless consonants across both languages remained distinct during the experiment. Presumably, it would be a change far to extensive, to lose aspiration in a predominantly long-lag aspirating language. Despite this, Subject 1 did shorten her voiceless VOT, although not significantly (see Fig. 7., red line pattern).

Overall, the VOT of both subjects has changed as predicted in the hypothesis, i.e. for Czech language, more cases of negative VOT, or prevoicing, have occured, and the positive VOT of voiceless consonants have shortened, becoming closer to that of short-lag native Czech speaker. English VOT has remained without any major changes for voiceless stops, supporting the hypothesis once more. The number of negative VOTs in English voiced consonants during Session 2 have nevertheless become an unexpected result.

5.2 Vowel Duration Experiment

The resulting Vowel Duration values were submited to a factorial ANOVA with Session (1 and 2), Vowel Type (Lax and Tense) and Voicing Coda (d = voiced, s = voiceless) as the indipendent variables, or factors for English vowels. Session (1 and 2), Vowel Lenght (Short and Long) and Quality Pair (/i, ɛ, a, o, u / and /i:, ɛ:, a:, o:, u:/) as indipendent variables.

5.2.1 Part one: Vowel Duration subject 1

5.2.1.1 English Vowel Duration

Subject 1 EM English	F	p
session	1,3	0,256

lax*tense	11,4	,002*
codaVoicing	237,2	0,000*
session*lax*tense	0,4	0,518
session*codaVoicing	4,5	,042*
lax*tense*codaVoicing	0	0,919
session*lax*tense*codaVoicing	0	0,831

Table 4 ANOVA Results for Subject 1, English Vowel Duration

The results for English vowel duration show that Session has no significant main effect (F(1, 35)=1,3319, p=,25629). Next, as expected, there has been a significant main effect found for vowel type (F(1, 35)=11,383, p=,00182). Furthemore, a voicing coda, unsurprisingly, also has a significant effect (F(1, 35)=237,17, p=0,0000) with overall mean duration 190ms during session 1 and 199,5ms during session 2. There has been no significant effect discovered in the interaction between Session and Vowel Type (F(1, 35)=,42659, p=,51793), although the overall mean Vowel Duration between sessions has slightly increased from 201ms to 216ms for tense vowels. No major changes were discovered for lax vowels (>5ms). Additionally, the interaction between Session and Voicing Coda has discovered a significant main effect (F(1, 35)=4,4671, p=,04175). When pooled over both sessions, vowels with Voiced Coda have lenghtened (244ms during S1 to 271ms during S2) and vowels with Voiceless Coda have shortened (136ms during S1 to 128ms during S2).

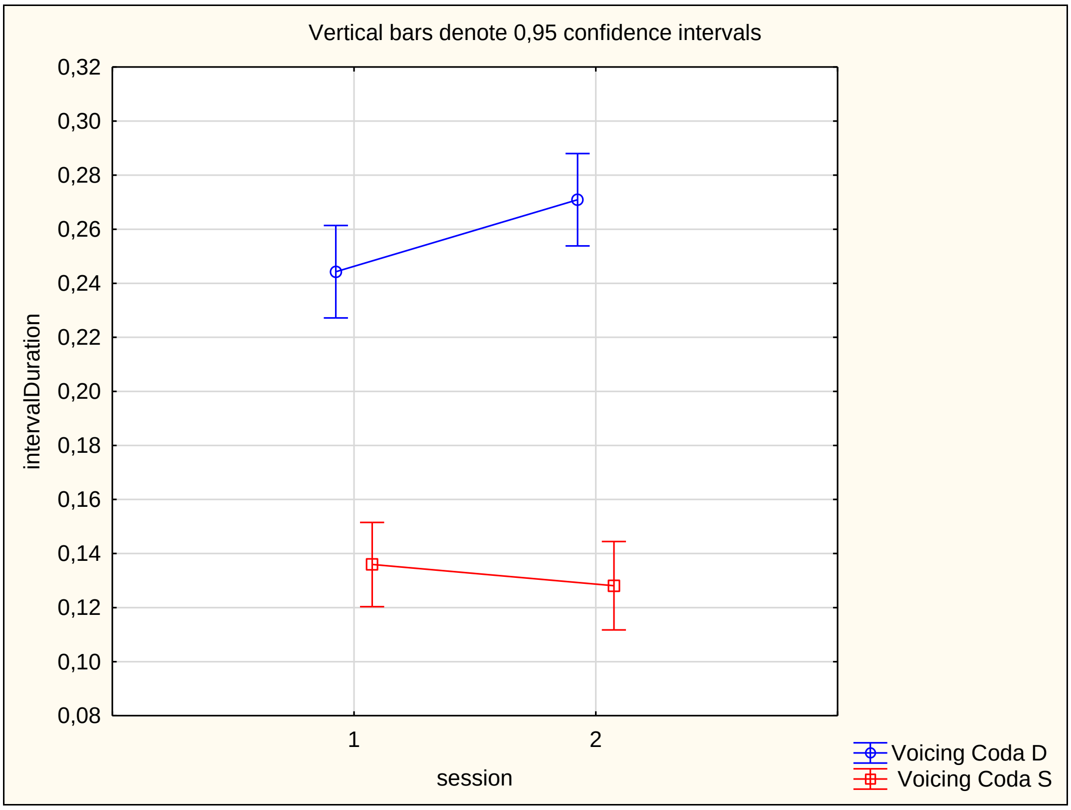

Fig. 12 – Interaction between Session and Voicing Coda

Voicing Coda and Vowel Type have interacted without any significance (F(1, 35)=,01051, p=,91894). The triple interaction between Session, Vowel Type and Voicing Coda has not resulted in any significant effect (F(1, 35)=,04613, p=,83118). For lax vowels, the interval duration has moved in the expected direction, i.e. the mean duration has shortened for vowels with Voiceless Coda and lenghtened for vowels with Voiced Coda. Similar movement was discovered in the Voiced Coda tense vowels, but without any changes for Voiceless Coda (>1ms).

5.2.1.2 Czech Vowel Duration

Subject 1 EM Czech	F	p
session	1,24	0,269
qualityPair	1,56	0,195
length	64,58	,000*
session*qualityPair	0,41	0,798
session*length	1,85	0,177
qualityPair*length	1,11	0,356
session*qualityPair*length	1,03	0,396

Table 5 – ANOVA Results for Subject 1, Czech Vowel Duration

Results for Czech vowel duration show, that except Length, which was expected, no factors or interaction between the factors have significant main effect on the vowel duration of Czech vowels. The interaction between Session and Length shows the closest approaching to significance (F(1, 76)=1,8531, p=,17744), but doesn't meet the criteria needed for a significant effect. Despite that, there is a movement in the duration of short vowels in the predicted direction, when pooled over sessions, specifically from 103ms during S1 to 124ms during S2. In

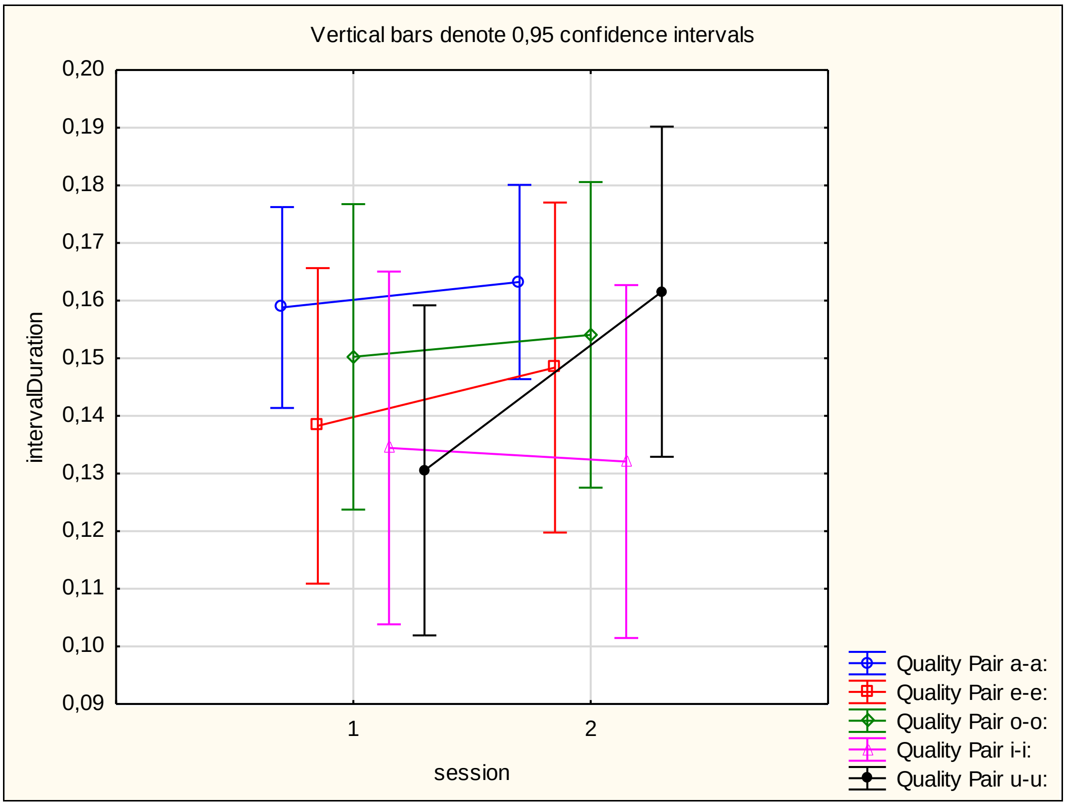

Fig. **13**, we can observe the changes in Vowel Duration for individual vowel quality pairs over Sessions. Seemingly the biggest change is visible for the u-u: pair (from 130ms during S1 to 161ms during S2). Nevertheless, the overall interaction between Session and Quality Pair has been found non-significant (F(4, 76)=,41356, p=,79836). If we compare the mean Vowel Duration from this part of the experiment with the initial statistics from section 2.3.5, we can clearly see that for Subject 1, the duration ratios within the quality pair come closer to that of native Czech speaker.

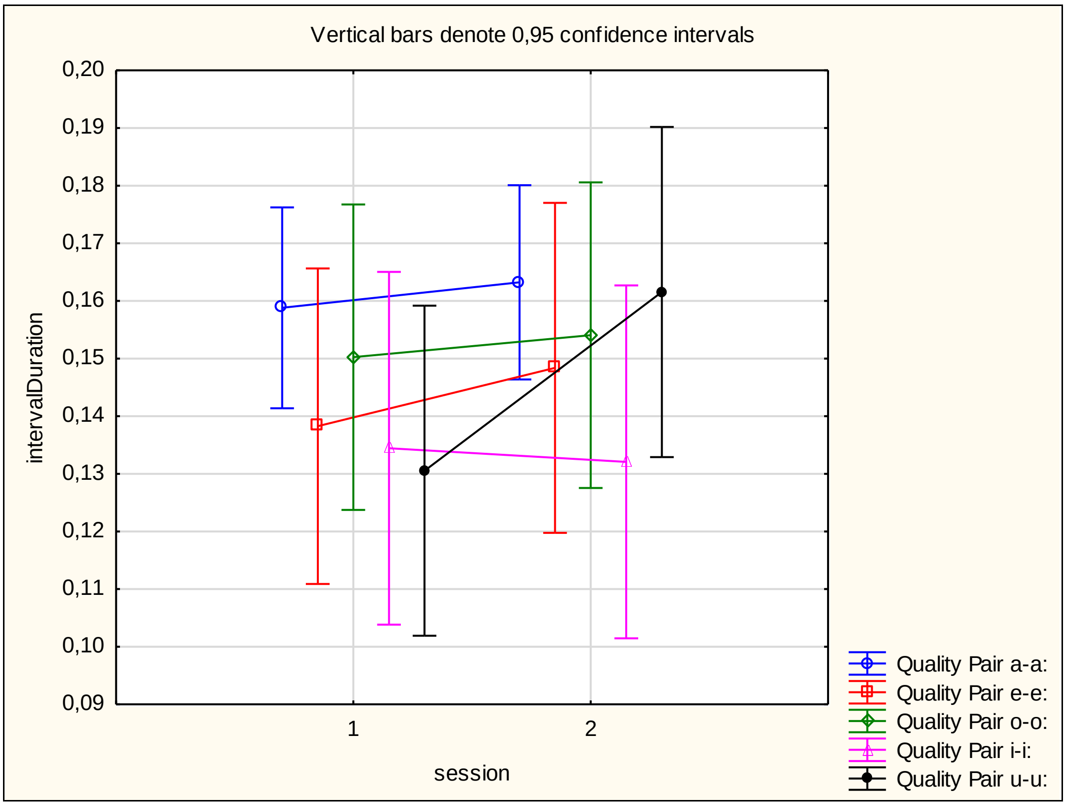

Fig. 13 – Interaction between Session and Quality Pair

5.2.2 Part two: Vowel duration subject 2

5.2.2.1 English Vowel Duration

Subject 2 KM English	F	p
session	1,49	0,229
lax*tense	5,1	,030*
codaVoicing	65,7	,000*
session*lax*tense	0,03	0,87
session*codaVoicing	0,07	0,799
lax*tense*codaVoicing	0,34	0,566
session*lax*tense*codaVoicing	0,12	0,726

Table 6 – ANOVA Results for Subject 2, English Vowel Duration

Results for English vowel duration show a significant main effect for Vowel Type, (F(1, 36)=5,1044, p=,03002), as well as for Voicing Coda (F(1, 36)=65,695, p=,00000), as expected. Session shows no significant effect (F(1, 36)=1,4945, p=,22946) and no interactions between the used variables have discovered a significant main effect. Interaction between Session and Voicing Coda, which has been significant for Subject 1, is non-significant for Subject 2 (F(1, 36)=,06561, p=,79929). There has been a tendency for overall lenghtening of Vowel Duration for both lax and tense vowels with both Voiceless and Voiced Coda over the Sessions.

5.2.2.2 Czech Vowel Duration

Subject 2 KM Czech	F	p
session	0,38	0,539
length	80,19	,000*
qualityPair	1,68	0,163
session*length	0,04	0,841
session*qualityPair	0,23	0,92
length*qualityPair	3,26	,016*
session*length*qualityPair	0,5	0,733

Table 7 – ANOVA Results for Subject 2, Czech Vowel Duration

The results for Czech Vowel Duration show no significant effect of Session Current effect: F(1, 80)=,38059, p=,53904or Quality Pair (F(4, 80)=1,6770, p=,16348). There is a significant main effect of Length (F(1, 80)=80,190, p=,00000), as was expected. Interaction between Session and Length have not resulted in any significant main effect (F(1, 80)=,04061, p=,84080), but the overall results show a slight shortening tendency (>10ms for short vowels and >5ms for long vowels). The interaction between Session and Quality Pair has shown a non-significant effect as well (F(4, 80)=,23203, p=,91960). Next, there has been a significant rection of Length and Quality Pair (F(4, 80)=3,2633, p=,01565). The triple reaction of Session, Lenght and Quality Pair shows no significant effect as well.

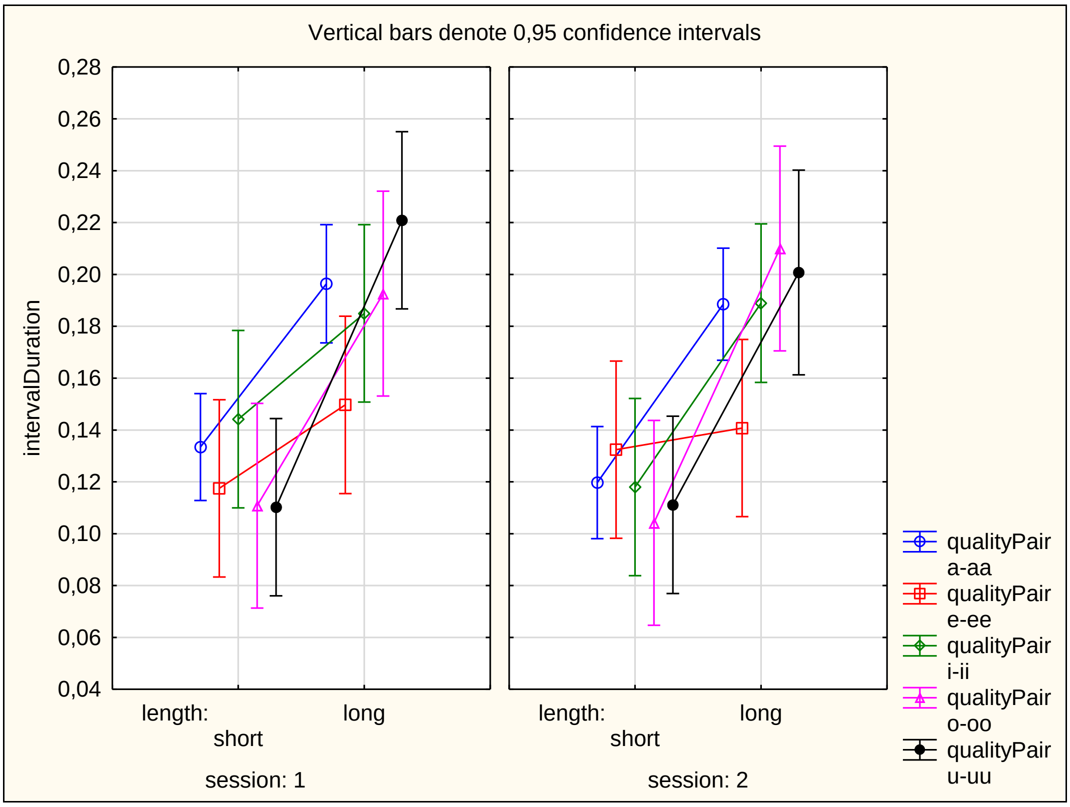

Fig. 14 – Triple interaction between Session, Length and Quality Pair

5.2.3 Discussion: Vowel Duration Experiment

Unlike the first part of the experiment, the Vowel Duration measuring has produced mostly ambiguous results. The prediction for the English part of the experiment has largely been confirmed, meaning the duration of vowels in English words did not shorten or lengthen in any unexpected way. Czech Vowels, however, do show a movement towards the mean average from section 2.5.2. in both cases. In Fig 13, the difference between Sessions 1 and 2 seem arbitrary, but when we measure the ratio between the individual vowel pairs from each session, it is clear, that the ratio from Session 2 moves closer towards native Czech speaker's. In section 5.2.1.2, the reaction of Session and Quality Pair results in a significant effect solely on the vowel pair /u/ and /u:/, but that might have occured only by chance, and the amount of material with target vowel in this case is not sufficient for any assumptions. In sum, the results of Vowel Duration experiment have not produced any significant results to support the initial hypothesis, arguably due to lack of samples or inadequate ratio of target vowel usage in the recording experiment. On the other hand, Session 1 results already show a mean vowel duration difference between the languages.

6 Final Discussion

This thesis provided a case study based on two bilingual subjects (Czech and English) and was focusing on the phonological changes in their VOT and vowel duration. By conducting the experiment over time, with two sessions aproximately 2 months apart, both subjects have succesfully demonstrated the Gestural drift, i.e. the shifting of their phonological acoustic properties towards being more native-like, and specifically shortening their VOT in voiceless stop initial words in Czech language, thus shifting their stop production closer to that of native Czech speaker. Their VOT for Czech voiced stops has also shortened, and more cases of prevoicing, e.g. negative VOT has occured, and the results supported H1. Both subjects displayed nearly identical changes and their VOT values have shifted in similar direction, which could be viewed as a proof of the theory given in section 2.5. Although the vowel duration experiment has not provided enough sufficient results to determine whether the Drift has in fact occured or not, it was succesfull in a sense that the mean duration of the Czech vowels was closer to the values of native Czech speaker shown in Fig. 1.

Because the subjects are English dominant (heritage) bilinguals with Czech language being used only to speak to the relatives from Czech republic, the changes in their Czech language were more relevant for this study. From logical point of view, a language that is used only rarely will likely change more radically than their dominant language, which they use in the vast majority of time.

7 Apendix

7.1 Word lists used

Following words were used for the Czech part of VOT experiment for both subjects:

Balón	Den	Píst	Pytel
Batoh	Diplom	Pátek	Tupý
Beton	Divoch	Pelech	Tapír
Bez	Doma	Pot	Táta

Binec	Dáma	Pes	Tabák
Bomba	Démon	Pivo	Tělo
Bota	Dívka	Kus	Tíha
Byt	Děkuji	Pak	Tužka
Bál	Dělo	Kotel	Tis
Bílá	Důkaz	Pero	Ticho
Bůček	Kafe	Topení	
Datel	Kilo	Tep	
Dav	Půl	Teplo	

Following words were used for the English part of VOT experiment for both subjects:

Bad	Cop	Git	Pit
Ban	Dab	Good	Pud
Bat	Dad	Kit	Tab
Beak	Dam	Pad	Tad
Bed	Dan	Pan	Tan
Bet	Dap	Pat	Tap
Big	Deed	Paul	Tea
Bill	Deep	Paw	Ten
Bin	Den	Pea	Tin
Bit	Dig	Ped	Tip
Bow	Dip	Pet	Top
Bud	Dot	Pill	
Cap	Gap	Pin	

Following words were used for the Czech part of Vowel Duration experiment for both subjects:

Bazén	Dráha	Péct	Móda
Drahá	Hrát	Réva	Ozón
Hrad	Máj	Být	Pórek
Mají	Pádlo	Kmín	Kus
Padat	Pán	Pít	Sluj
Paní	Stát	Vír	Tuk
Plakat	Válí	Byt	Uhel
Radí	Jmelí	Kmit	Kůň
Rádi	Pec	Pita	Tůň
Statek	Plena	Vir	Úhel
Valí	Pléno	Modrá	
Akát	Ret	Otok	
Báze	Jméno	Pot	

Following words were used for the English part of Vowel Duration experiment for both subjects:

Bad	Bid
Cab	Bit
Cap	Pit
Tab	Ship
Tap	Beak
Cod	Beat
Don	Bede
Sawed	Pete
Sod	Sheep
Stock	Food
Thought	Foot
Bed	

7.2 CD

On the inside of the back cover, a CD is attached, containing the digital copy of the thesis

8 Bibliography used

Adler, M. K. (1977). Collective and individual bilingualism: A sociolinguistic study. Buske Verlag.

Antoniou, M., Best, C. T., Tyler, M. D., & Kroos, C. (2011). Inter-language interference in VOT production by L2-dominant bilinguals: Asymmetries in phonetic code-switching. Journal of Phonetics, 39(4), 558-570.

Asher, J. J., & Garcia, R. (1969). The optimal age to learn a foreign language. The Modern Language Journal, 53(5), 334-341.

Balukas, C., & Koops, C. (2015). Spanish-English bilingual voice onset time in spontaneous code-switching. International Journal of Bilingualism, 19(4), 423-443.

Bhatia, T. K., & Ritchie, W. C. (Eds.). (2008). The handbook of bilingualism. John Wiley & Sons.

Boberg, C. (2008). Regional phonetic differentiation in standard Canadian English. Journal of English Linguistics, 36(2), 129-154.

Brown, E. K., & Copple, M. T. (2018). Constructing two phonological systems: A phonetic analysis of/p/,/t/,/k/among early Spanish–English bilingual speakers. *International Journal of Bilingualism*, *22*(1), 51-68.

Caramazza, A., Yeni-Komshian, G. H., Zurif, E. B., & Carbone, E. (1973). The acquisition of a new phonological contrast: The case of stop consonants in French-English bilinguals. The Journal of the Acoustical Society of America, 54(2), 421-428.

Charlotte, H. (1991). An introduction to bilingualism.

Chang, C. B. (2013). A novelty effect in phonetic drift of the native language. Journal of Phonetics, 41(6), 520-533.

Cook, V. J. (2002). Background to the L2 user. In V. J. Cook (Ed.), Portraits of the L2 user (pp. 1–28). Clevedon: Multilingual Matters.

Escudero, P. (2007). Second-language phonology: The role of perception. In Phonology in context (pp. 109-134). Palgrave Macmillan, London.

Escudero, P., & Polka, L. (2003). A cross-language study of vowel categorization and vowel acoustics: Canadian English versus Canadian French. In Proceedings of the 15th International Congress of Phonetic Sciences (pp. 861-864). Barcelona: Futurgraphic.

Flege, J. E., MacKay, I. R., & Piske, T. (2002). Assessing bilingual dominance. Applied Psycholinguistics, 23(4), 567-598.

Fowler, C. A., Sramko, V., Ostry, D. J., Rowland, S. A., & Hallé, P. (2008). Cross language phonetic influences on the speech of French–English bilinguals. Journal of Phonetics, 36(4), 649-663.

Goldrick, M., Runnqvist, E., & Costa, A. (2014). Language switching makes pronunciation less nativelike. Psychological science, 25(4), 1031-1036.

Flege, J. E., Schirru, C., & MacKay, I. R. (2003). Interaction between the native and second language phonetic subsystems. *Speech communication*, *40*(4), 467-491.

Hambly, H., et al. (2013). The influence of bilingualism on speech production: A systematic review. *International Journal of Language & Communication Disorders*, *48*(1), 1-24.

Holm, A., & Dodd, B. (1999). A longitudinal study of the phonological development of two Cantonese–English bilingual children. *Applied Psycholinguistics*, *20*(3), 349-376.

Johnson, J. S., & Newport, E. L. (1989). Critical period effects in second language learning: The influence of maturational state on the acquisition of English as a second language. Cognitive psychology, 21(1), 60-99.

Ladefoged, P., & Johnson, K. (2014). A course in phonetics. Nelson Education.

Machač, P., & Skarnitzl, R. (2009). *Principles of phonetic segmentation*. Epocha.

Macken, M. A., & Barton, D. (1980). The acquisition of the voicing contrast in English: A study of voice onset time in word-initial stop consonants. Journal of Child Language, 7(1), 41-74.

Miller, J. L., Green, K. P., & Reeves, A. (1986). Speaking rate and segments: A look at the relation between speech production and speech perception for the voicing contrast. Phonetica, 43(1-3), 106-115.

Moyer, A. (1999). Ultimate attainment in L2 phonology: The critical factors of age, motivation, and instruction. Studies in second language acquisition, 21(1), 81-108.

Piske, T., MacKay, I. R., & Flege, J. E. (2001). Factors affecting degree of foreign accent in an L2: A review. Journal of phonetics, 29(2), 191-215.

Podlipský, V. J., Skarnitzl, R., & Volín, J. (2009). High front vowels in Czech: A contrast in quantity or quality?. In Tenth Annual Conference of the International Speech Communication Association.

Sancier, M. L., & Fowler, C. A. (1997). Gestural drift in a bilingual speaker of Brazilian Portuguese and English. Journal of phonetics, 25(4), 421-436.

Sussman, H. M., Franklin, P., & Simon, T. (1982). Bilingual speech: Bilateral control?. Brain and language, 15(1), 125-142.

Tobin, S. J., Nam, H., & Fowler, C. A. (2017). Phonetic drift in Spanish-English bilinguals: Experiment and a self-organizing model. Journal of Phonetics, 65, 45-59.

Wei, L. (Ed.). (2000). The bilingualism reader. Psychology Press.

Wells, J. C. (1982). Accents of English (Vol. 3). „Beyond the British Isles“. Cambridge University Press.

Šimáčková, Š., Podlipský, V. J., & Chládková, K. (2012). Czech spoken in Bohemia and Moravia. Journal of the International Phonetic Association, 42(2), 225-232.