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Patterns of Short-Term Phonetic Interference in Bilingual Speech

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Abstract: Previous research indicates that alternating between a bilingual's languages during speech production can lead to short-term increases in cross-language phonetic interaction. However, discrepancies exist between the reported L1–L2 effects in terms of direction and magnitude, and sometimes the effects are not found at all. The present study focused on L1 interference in L2, examining Voice Onset Time (VOT) of English voiceless stops produced by L1-dominant Czech-English bilinguals—interpreter trainees highly proficient in L2-English. We tested two hypotheses: (1) switching between languages induces an immediate increase in L1 interference during code-switching; and (2) due to global language co-activation, an increase in L1-to-L2 interference occurs when bilinguals interpret (translate) a message from L1 into L2 even if they do not produce L1 speech. Fourteen bilinguals uttered L2-English sentences under three conditions: L2-only, code-switching into L2, and interpreting into L2. Against expectation, the results showed that English VOT in the bilingual tasks tended to be longer and less Czech-like compared to the English-only task. This contradicts an earlier finding of L2 VOT converging temporarily towards L1 VOT values for comparable bilingual tasks performed by speakers from the same bilingual population. Participant-level inspection of our data suggests that besides language-background differences, individual language-switching strategies contribute to discrepancies between studies.

Keywords: code-switching; interpreting; language mode; cross-language phonetic interference; voice onset time

1. Introduction

This paper focuses on one specific bilingual situation and one specific type of bilingual speaker—advanced foreign language learners, namely native speakers of Czech who learned English at school. In a linguistically homogeneous country like the Czech Republic, where 98% of the population speaks the majority language (European Commission 2006), classroom instruction is the most common route to bilingualism. We recruited participants from successful language learners who can be described as L1-dominant successive bilinguals highly advanced in L2. With the exception of one participant, they all started learning English by the age of eleven and they were late bilinguals, in the sense of coming into sustained contact with native speakers only in adolescence. Expected for such a type of bilinguals is the transfer of L1 features into their L2 (Green 1998; Linck et al. 2012), which, on the level of sound, results in foreign-accentedness. Interestingly, recent studies have revealed that phonetic cross-linguistic influence (including L1-to-L2 interference) can momentarily increase when a bilingual performs in the bilingual language mode (Grosjean 2008), that is, when both their languages are engaged simultaneously (for references see Sections 1.2 and 1.3). We examined the phonetic influence of our learners' L1 Czech on their English spoken productions in terms of one acoustic measure—Voice Onset Time (VOT). Specifically, we tested whether the degree of L1-to-L2 phonetic transfer changes as a function of using one language as opposed to alternating between languages.

1.1. Dual Language Use

Bilingualism affects not only speakers' long-term memory representations of speech sounds, words, or grammatical structures, but also their online language processing. Importantly, bilinguals do not completely "turn off" the language that is not required by the current communicative situation (or an experimental task); instead, the non-target language remains activated to some degree. Such co-activation occurs not only during the automatic process of decoding language but also during the controlled process of language production. Evidence for language co-activation is found, for instance, in tasks which are overtly monolingual but employ words with covert links to the bilingual's other language (e.g., cognates and cross-language homophones). Within-subject comparisons reveal differential treatment of such words compared to the truly single-language stimuli. Relevant to the current study of L1 transfer in foreign language learners' L2 speech is the finding that the co-activation effects are modulated by speakers' language proficiency: more robust cross-language effects are found when bilinguals perform in their weaker L2. It is the dominant L1 that such bilinguals cannot turn off (e.g., Costa et al. 2000; Starreveld et al. 2014).

Unique to bilinguals is their ability to engage in discourse involving multiple languages, for example, in conversations during which interlocutors code-switch (use two languages within a single utterance) or during which online inter-language translation, that is, interpreting, is required by the presence of monolinguals. In such situations, most fluent bilinguals can alternate between their languages smoothly and rapidly. The question addressed here is to what extent a bilingual speaker's languages are kept separate when performing in the bilingual mode. Specifically, we are interested in inter-lingual influences evident in bilinguals' phonetic realization of utterances. Do bilinguals experience increased cross-language phonetic interference when alternating between languages—presumably due to greater language co-activation—compared to single-language productions?

In the following two sections, we discuss first psycholinguistic research into the phonetic effects of engaging two languages in online production tasks, and second, the phonetic consequences of experimentally induced and naturalistic code-switching within a single utterance.

1.2. Psycholinguistic Studies of Phonetic Consequences of Language Switching

Psycholinguistic studies of cross-language sound interactions during online language processing induce simultaneous engagement of a bilingual's languages either overtly, via the explicit requirement to switch languages on cue, or covertly, for example, via a monolingual task involving cognates. In many studies, the phonetic reflexes of bilingual language use are operationalized in terms of VOT, a temporal acoustic measure expressing the duration of the interval between the release of a stop consonant closure and the onset of vocal fold vibration. Such language pairs are examined in which each language uses different VOT settings to achieve the voicing contrast in stop consonants, for example, Spanish versus English. Using a picture-naming task, a recent switching study with Spanish-English bilinguals (Goldrick et al. 2014) showed that native speakers of Spanish produce less English-like VOT of word-initial stop consonants /t, d/ in English words immediately following a switch from Spanish. Switching from L2 English to the dominant L1 Spanish did not induce a VOT shift. The phonetic effect of the unexpected, externally cued, switching into English was especially evident for words with existing Spanish cognates. The authors interpret their results in terms of the cascade hypothesis of speech production that allows the activation of phonological and phonetic information of potential non-selected lemmas (Costa et al. 2000; Dell et al. 2014). Thus, the partial activation of a non-selected lexical representation (e.g., the lemma of the Spanish word *teléfono* when naming a picture of a telephone in English) affects later stages of processing, that is, the encoding of the phonological form and subsequent phonetic coding.

Language dominance did not modulate the effect of switching on the pronunciation of Catalan mid back vowels in (Simonet 2014), one of the few studies not measuring VOT. In two shadowing tasks, the Catalan and Spanish bilinguals either produced Catalan sentences or switched between sentences in their two languages, both equally represented. The cognate status of many of the target words must have promoted cross-language activation even in the Catalan-only condition. However, the difference between the Catalan-only and the bilingual Catalan-Spanish conditions suggests a switching-induced effect: the quality of Catalan vowels /ɔ/ and /o/ shifted towards the Spanish /o/ as a result of switching.

The influence of the cognate status on bilinguals' phonetic implementation of words has also been observed in experiments using non-switching, single-language production tasks (Brown and Amengual 2015; Mora and Nadeu 2012). In one proposal (Amengual 2012), cognate phonetic effects were accounted for by integrating the cascaded production model with the exemplar theory of lexical representation, according to which words are stored in memory as sets or clouds of phonetically richly specified exemplars (Pierrehumbert 2001, 2002). If cognates have bilingual exemplar connections, that is, bilinguals associate the phonetically overlapping exemplars of a cognate word from both languages in the same cloud, their production targets for the sounds in that word, averaged over all the exemplars, will differ from the production targets of the same sounds in non-cognate words. While Amengual (2012) reported the effect of cognates on VOT to be independent of language experience, that is, present in both heritage speakers and L2 learners, Jacobs et al. (2016) found this effect only for their intermediate L2 classroom learners but not for intermediate L2 immersion learners or for highly proficient learners.

Interestingly, cognates were deliberately avoided in another VOT study of language-switching effects, in order "to minimize any cross-linguistic activation" (Olson 2013, p. 411). Here, L1-to-L2 transfer was not observed for English/Spanish bilinguals; however, VOT in the bilinguals' dominant L1 was affected by the immediate prior use of L2—switching from L2 into L1 during picture-naming induced a shift in the phonetic execution of word-initial voiceless stops in the direction of L2. Since the target words were not cognates, a simultaneous activation of overlapping phonological representations could not have produced the VOT shift. The effect was present when the amount of switching was minimal and the bilinguals spoke mainly in L2, pronouncing only 5% of the words in their L1. The unidirectional impact of the bilinguals' weaker L2 on the dominant L1 is explained in terms of inhibition. Greater levels of inhibition are required when bilinguals speak in their weaker L2 because they are suppressing the stronger L1. If they switch into the L1, following naming in L2, "residual inhibition on the previously inhibited L1 phonetic system leads to L2-to-L1 transfer" (ibid., p. 418).

1.3. Phonetic Studies of Code-Switching

The phonetics of bilingual speech has been further explored via a variety of experimental code-switching paradigms, as well as by analyses of spontaneous code-switches in bilingual corpora. Typically, VOT of stop consonants is compared when L2 and L1 sounds are produced in a single-language situation (monolingual mode) and when they appear in code-switched utterances (bilingual mode). Like the language-switching studies above, code-switching studies use within-subject comparisons to test for short-term, momentary variation in phonetic implementation of the target sounds induced by the bilingual mode. However, unlike the language-switching studies, which ultimately analyse phonetics of single words uttered in one of the bilingual's languages, studies of code-switching examine words embedded in two-language utterances. Their rather disparate outcomes are indicative of the fluctuability inherent in the phonetic reflexes of code-switching.

An older, frequently cited study (Grosjean and Miller 1994) tested the effect of code-switching on VOT during story retelling and during sentence reading by French-English bilinguals when single English words were inserted into an otherwise French-monolingual context. The speakers did not produce a significant VOT difference for English /p, t, k/ when code-switching from L1 French into L2 English compared to performing in the single-language English mode. The authors concluded that switching "usually involves a total change, not only at the lexical but also at the phonetic level" (ibid., p. 205). Interestingly, code-switching in this case corresponded to insertion into French utterances of English words that phonologically overlapped with their French counterparts. Unlike in language switching (Goldrick et al. 2014; Simonet 2014), the use of cognates in this code-switching context did not lead to phonetic convergence.

More recently, support for momentary increases in cross-language influence was reported in a study comparing English/Spanish late bilinguals' VOT of word-initial /p, t, k/ elicited in each language in the single-language mode and during code-switching: the bilinguals started reading a sentence in one language and completed it in another (Bullock et al. 2006). Several interesting outcomes emerged. Firstly, code-switching shortened English VOTs but did not extend Spanish VOTs, regardless of the direction of the switch, for both L1-Spanish and L1-English bilinguals. The unidirectionality of the effect was ascribed to the fact that the range of VOT values is wider in the English long-lag voiceless stops compared to the compressed VOT range in the Spanish short-lag voiceless stops, and hence shifts in VOT induced by code-switching are more likely in English (see also Bullock and Toribio 2009). Secondly, shortening of English VOT was observed if the English stop occurred immediately after Spanish had been spoken, that is, at the site of the switch but not if it occurred 2–3 syllables later, reflecting transience of the code-switching effect. Moreover, the greatest shortening of English VOT occurred, not after switching from Spanish, but before switching from English into Spanish, suggesting the effect of planning the post-switch part of the utterance. Unexpectedly, the L1 English bilinguals reduced the pre-switch VOT values not only of their English but also of Spanish /p, t, k/. Possibly, they shifted their production in a divergent way in the effort to enhance the VOT difference between their two languages. In Bullock and Toribio (2009), a similar pattern of results for English /p, t, k/ was observed with the code-switching effects on the Spanish stops varying according to the language dominance of the speakers. The cognate status of the target words was not discussed in either of the studies although the examples of the stimuli suggest that the targets were not English-Spanish cognates. Interestingly, using the same stimuli as Bullock et al. (2006) and Bullock and Toribio (2009), another study found only a weak indication of short-term interference in VOTs of /p, t, k/ elicited from English late learners of Spanish (López 2012). The effect was greatly modulated by the place of articulation, possibly because acquisition of VOT presents L2 learners with different degrees of difficulty for labials, alveolars and velars.

Corroborative of short-term interference is Experiment 1 in Antoniou et al. (2011), examining VOT of /b, d, p, t/ produced by early Greek-English bilinguals either in the Greek monosyllable C[a] embedded in an English carrier sentence 'Say __ again' or in English C[ɑ] embedded in the equivalent Greek carrier (English and Greek use different alphabets). Similar to Bullock et al. (2006), inter-lingual influence induced by code-switching was observed in the long-lag language (English) but not in the short-lag language (Greek): in the bilinguals' dominant (but second) language—English—the stops became more Greek-like, while in their non-dominant (but first) language—Greek—the stops seemed unaffected by switching between the languages. The question remains whether the direction of the inter-lingual influence depends on the order of acquisition of the bilinguals' languages, L1 exerting persistent influence over L2—as suggested by the authors—or on the type of VOT categories in each language, as proposed in Bullock et al. (2006), or both.

In contrast to the minimalistic stimuli used in Antoniou et al. (2011), contextualizing texts were constructed in Olson (2016a), each ending in a sentence containing a *p/t/k*-initial target word, non-cognate in English and Spanish. To simulate variability along the monolingual-to-bilingual mode continuum, the target word was either in the same language as the rest of the text, or it was the only code-switch in an otherwise monolingual text, or it was preceded by several code-switches in a language-balanced bilingual text. The texts were read by late Spanish-English bilinguals counterbalanced for language dominance. For the L1-English-dominant bilinguals, the VOT of the English stops were more Spanish-like if they occurred in a code-switched target word. The L1 Spanish-dominant bilinguals showed a bidirectional effect, their VOT shifting both in the English and in the Spanish code-switches. Unexpectedly, the VOTs in the English words produced after switching from Spanish, though shortened compared to English words preceded by production in English, were longer (i.e., less Spanish-like) in the texts with multiple switches compared to texts with a single switch. Taken together, the results confirm the susceptibility of long-lag stops to cross-language interference—the long VOT of English stops was always shortened due to code-switching; the short Spanish VOT was not always extended. Importantly, the code-switches showed phonetic effects irrespective of the amount of switching in the texts.

Whereas all the studies summarized above relied on carefully controlled scripted data, other studies have analysed spontaneous code-switching. The relationship between VOT of initial voiceless stops and the time that elapsed since the moment of switching was examined in the speech of early L1-Spanish L2-English bilinguals living in a bilingual Spanish-English community in Balukas and Koops (2014). Again, an asymmetrical result for the long-lag English versus the short-lag Spanish stops was observed. For all three English voiceless stops, VOT values increased, that is, became more English-like, within the first few seconds after the Spanish-to-English switching site, suggesting the weakening of phonetic interference from the pre-switch Spanish. VOT values of Spanish /p, t, k/, on the other hand, remained unaffected by English-to-Spanish code-switching. The authors argued that a universal perceptual constraint on short-VOT realizations is responsible for such unidirectionality, suggesting an upper limit of 30 ms for short-lag stops, based on Lisker and Abramson (1964).

duration

Another study focusing specifically on the long VOT of English /p, t, k/ in spontaneous code-switches of balanced English-Spanish bilinguals (Fricke et al. 2016) found only anticipatory influence of Spanish on the English targets, that is, the English long-lag stops shortened before the speakers' switching into Spanish. Like in Balukas and Koops (2014), the effect of code-switching on VOT was localized; English stops occurring closest to the point of switching into Spanish had the shortest VOT values. By contrast, in Piccinini and Arvaniti (2015), the distance of the target stop from the switch point did not significantly affect VOT, although the early English-dominant Spanish/English bilinguals did produce VOT changes due to code-switching in both languages. This suggests a more global influence of the bilingual mode. In addition, a greater effect was observed in L2 English where code-switching led to a convergence to the Spanish values, that is, VOT of English /p, t, k/ shortened. In Spanish code-switches, the stops exhibited divergence from English, their VOT becoming even shorter than it is typical for Spanish and even less English-like.

Considering the reviewed code-switching studies together, several points emerge with respect to the phonology of code-switched targets. First, the phonological overlap of the target words with its equivalent in the other language, such as in cognates, is not necessary for short-term VOT shifts to occur. In fact, the only code-switching study reviewed above that systematically employed cognates found no phonetic impact of code-switching (Grosjean and Miller 1994). Second, some phonetic categories are more malleable and may reflect cross-language influences more than others. The VOT of long-lag voiceless stops is more likely to shift (or to shift more) as a result of interference from a language with short-lag stops than the other way around. Finally, in terms of VOT, cross-language interaction often results in a converging shift towards the equivalent phonetic category of the other language; however, some studies also demonstrated divergent phonetic shifts.

As to what underlies the cross-language VOT effects, the distance from the switch-site seems relevant. The effects may be local, that is, evident only when stop consonants are in the close proximity of the switch, or they may last longer. The local cross-language interaction often happens in anticipation of the switch but may also affect the first syllables spoken after the switch. Anticipatory effects might arise because speech production is incremental—a bilingual speaker is planning the upcoming switched item (hence activating the phonology of the language of the switch) while encoding the phonetic form of words or syllables preceding the switch. In carry-over effects, the ongoing articulation of sounds before the switch might affect the articulatory planning of the switch. Global code-switching effects, such as cross-language influence on phonetic implementation of words distant from the switch, have also been reported. They are likely to arise in situations that require the bilinguals to maintain an overall high activation of both languages.

A global effect of the bilingual mode has been observed experimentally in Olson (2013), the language-switching study summarized in Section 1.2. Recall that the study used a cued picture-naming task. In the multiple-switches condition, speakers named half of the randomly presented items in English and half in Spanish. In the few-switches condition, they named 95% of items in one language—English or Spanish—and only 5% in the other. Relevant here is the bilinguals' pronunciation of non-switches (i.e., words that are in the same language as the immediately preceding word). The VOT of non-switches in the bilingual multiple-switches condition was similar to the VOT of the switched items in that condition but it differed from the VOT of non-switches in the few-switches context: in the bilingual mode, the VOT produced in Spanish non-switches was longer, more English-like and vice versa, English VOT produced in English non-switches was shorter, more Spanish-like. The result can be explained as an overall increase of short-term cross-language influence due to high co-activation of both the languages in the bilingual mode. Such a longer-lasting phonetic effect of language switching parallels the global naming latency costs reported in language switching studies of lexical access (Olson 2016b). For instance, this was the case in Christoffels et al. (2007), whose L1-dominant bilinguals showed in L1 slowed-down naming latencies and stronger cognate facilitation on stay trials in mixed language blocks compared to single-language blocks, or in Gollan and Ferreira (2009), whose balanced bilinguals named pictures more slowly on stay trials when mixing languages compared to unilingual naming. A global effect of dual language use was observed in a recent tip-of-the-tongue study; a comprehension task performed in the bilinguals' L1 generated an increase in TOT occurrences during their subsequent L2 production (Kreiner and Degani 2015). For code-switching, despite some indications of long-distance, that is, non-local influence of language alternation (Piccinini and Arvaniti 2015), global effects have not been clearly demonstrated. In Olson (2016a), a code-switching study in which the degree of dual language activation was manipulated, the local and global effects did not cumulatively add up; a single code-switch in a monolingual paragraph induced a similar VOT shift (compared to a completely monolingual production) as did a code-switch in a paragraph with an equal amount of material from both languages.

above and beyond CS effect

It is important to keep in mind that while the code-switching phonetic effects, such as VOT shifts, are measurable and more or less consistent, they are subtle, fine-grained shifts on the order of several milliseconds that do not result in between-category switches involving phonemes or features. They are rapid and transitory adjustments to the bilingual mode of language use that most likely arise during the execution of articulation rather than being phonological planning errors. These phonetic implementation effects seem to be constrained by a bilingual speaker's language experience: the pattern of L1 and L2 acquisition and use, and the resulting language proficiency and dominance. In addition, phonetic cross-language effects might also be modulated by a bilingual's experience with switching languages and tasks in general. One language-switching study showed that bilinguals who reported frequent switching between languages in daily life switched faster both between languages and between non-linguistic tasks, showing an advantage in executive control (Prior and Gollan 2011). Better executive control has, in turn, been shown to lead to a better separation of bilinguals' long-term L1 and L2 phonological representations (Lev-Ari and Peperkamp 2013) and it is possible that it may be involved also in better articulatory control.

2. Motivation for the Current Study

In Šimáčková and Podlipský (2015), a study which preceded our current investigation, we explored the effects of bilinguals' language-switching experience on the phonetic implementation of L2 voiceless stops /p, t/ during dual versus single language use. The purpose of that study was three-fold. We first sought to test the robustness of the impact of code-switching on VOT with another short-lag language—Czech—and with bilinguals who learned their L2—long-lag English—in an instructional setting. Thus, we asked whether code-switching would increase L1-to-L2 phonetic interference in late Czech-English bilinguals' speech as compared to single-language L2 productions.

Further, we aimed to test the impact of experience with language switching. Interpreters have extensive training in switching between languages and may therefore be more successful in suppressing the activation of the unintended language than other bilinguals. Accordingly, we also asked whether training in interpreting would reduce immediate L1-to-L2 phonetic interference. Finally, an additional goal was to examine the global impact of performing in the bilingual mode. The degree of language co-activation was manipulated by adding (or not) on-line interpreting to the code-switching task. We reasoned that the level of L1 activation is increased when planning L2 production is based on a memory of an utterance received in L1. Such co-activation of L1 and L2 could momentarily increase cross-language influence in a way that simple code-switching does not. Thus, we asked whether the phonetic L1-to-L2 interference in code-switched utterances would increase when the bilingual has to translate the L2 part of the code-switched utterance from L1.

The overall results of Šimáčková and Podlipský (2015) showed that the bilingual productions of voiceless stops in the bilingual tasks were indeed more L1-like compared to the baseline productions in the L2-only task. However, the effect of language mode was modulated by a bilingual's phonetic accuracy; short-term L1-to-L2 interference was found only for those native speakers of a short-lag language (Czech) who could produce English /p/ or /t/ with sufficiently long VOT values. Bilinguals whose L2 stops had rather short, more L1-Czech-like VOTs in the L2-only task to begin with did not show any further shortening in the bilingual tasks ascribable to a momentary increase in L1 interference. Thus, in order to show mode-induced variation, the bilinguals must realize the long-lag L2 English stops with a sufficiently L2-like extended VOT. This finding added to the reports of long lag voiceless stops being more susceptible to VOT shortening in code-switched utterances than short lag voiceless stops (e.g., Bullock et al. 2006; Bullock and Toribio 2009).

A bilingual's experience with alternating between languages, operationalized as the amount of interpreter training, was not reflected in an improved ability to switch completely between L1 and L2 phonetic categories. Neither did the results support the expectation of a gradient increase in phonetic interference due to interpreting: no difference in VOT between the two bilingual tasks was found. Similar to Olson 2016a, we found phonetic effects of code-switching not to be cumulative.

In the current study, we first wanted to see if we can replicate the VOT shift observed in the speech of advanced Czech EFL trainee interpreters during the bilingual tasks that we reported in Šimáčková and Podlipský (2015). A comparison of phonetic code-switching effects across studies shows that short-term shifts induced by language mode are not always found. This is the case even when the same L1-L2 combination and the same elicitation procedure are used as in (Bullock et al. 2006) on one hand and in (López 2012) on the other. Differences in the age of learning, language dominance and proficiency are often used to account for the discrepancies. Thus, we reasoned that replicating a study with bilinguals matched for these attributes while using a near-identical methodology would confirm robustness of the phonetic code-switching effect. The second goal was to explore further the possibility of a more global impact of the bilingual mode on VOT of long-lag voiceless stops. In Šimáčková and Podlipský (2015), the increase in short-term L1-to-L2 interference observed in dual-language vis-a-vis single-language productions was similar both in simple code-switching and in code-switching combined with interpreting. In other words, adding the on-line translation did not have an additive effect on phonetic interference. In the current study, we wondered whether the phonetic interference induced by the interpreting condition would remain even when the interpreting task did not also involve a code-switch as it did in our previous study. Thus, we modified the interpretation task by removing the code-switch and compared the VOT of /p/ and /t/ with the data from Šimáčková and Podlipský (2015), henceforth Š&P2015, in the same statistical analyses.

We hypothesized that the answer to our second question—whether interpreting alone can produce a rise in L1-to-L2 interference for our L1-dominant bilinguals—would be positive. Continuous interpreting in one direction—from L1 into L2—albeit consecutive rather than simultaneous, requires active use of both languages. It relies on an accurate perception of L1 speech sounds for fast decoding of linguistic units and comprehension of L1 utterances, which must be stored in memory, reformulated and articulated in

L2. One-direction interpreting, however, also requires that only single-language utterances are produced, that is, no articulation of L1 sounds takes place. Thus, local phonetic interference of the kind observed in code-switching (e.g., Bullock et al. 2006; Fricke et al. 2016; Olson 2016a), whether anticipatory—i.e., induced by accessing post-switch phonetic forms while planning articulation of a pre-switch unit—or carry-over due to transfer of articulatory settings at the switch juncture, cannot occur. The phonetic cognate effect, evidenced in single-language psycholinguistic experiments, is also less likely in online Czech-to-English interpreting since, in general, the number of Czech-English cognates is limited and since specifically for the purposes of the current study, cognates were excluded. Consequently, we reasoned that if temporarily increased L1 phonetic interference in L2 emerges without involvement of specific lexical items during interpreting, such an effect can only be attributed to a global influence of dual language processing. If phonetic effects of L1-to-L2 interference were observed only in the code-switching but not in the interpreting condition, we could conclude that the effect of bilingual mode on the phonetic implementation sounds was strictly local.

3. Method

3.1. Stimuli and Procedure

The study compared the VOT of English voiceless stops /p, t/ in bilingual speakers' productions of 12 English target words under 3 conditions: monolingual-mode English condition (EN), code-switching (CS), and interpreting (IN). In all 3 conditions, the target words were 6 *p*-initial and 6 *t*-initial monosyllabic English words, with a non-high vowel after the initial stop (*pack*, *pain*, *pass*, *pear*, *pork*, *pub*, *tall*, *talk*, *ten*, *tie*, *toy*, *turn*). None of the target words had a cognate in Czech, nor did the Czech translation equivalents (*sbalit*, *bolest*, *složit*, *hruška*, *vepřové*, *hospoda*, *vysoký*, *mluvit*, *deset*, *zavázat*, *hračka*, *otočit*/*řada* respectively) contain a voiceless stop in the critical word-initial position. In the EN and CS conditions, for each target word two short English sentences (5–8 syllables) were constructed, one containing the target word in the initial position, the other in the final position. In the IN condition the closest Czech equivalent of each target word was placed in two short Czech sentences. A translation test involving 5 advanced learners of English not participating in the study confirmed that the Czech sentences would elicit production of the English target words in the desired positions. Altogether 24 sentences with the target words (2 places of articulation × 6 target words × 2 sentence positions) and 64 filler sentences were created per condition. While the target words were identical in the EN and CS conditions, the 88 sentences were different. In the IN condition, one half of the sentences were translations of the sentences from the EN condition and the other from the CS condition. Five native Czech speakers (3 females), aged 21–25, recorded the Czech sentences in the quote frame *Teď řeknu_* ('Now I will say_'). The English sentences were recorded by five native speakers of English in the quote frame *I should say_*. In order to constrain imitation, the English speakers were selected from both genders (3m, 2f), they had different ages (ranging between 24–54 years), as well as accent backgrounds (3 American English, 2 British English). Each speaker produced all the (Czech or English) sentences, but only one realization of each sentence by different speakers was selected for the final stimulus set. Prompting questions (see below) were recorded by the same speakers. The VOTs in the English speakers' 24 EN-condition sentences were measured to obtain reference data.

To further prevent imitation, we used a delayed repetition (EN, CS) and a translation (IN) task. As schematized in Table 1, in the EN condition participants heard an English sentence (e.g., *We like the new pub*) followed by the English prompt *What should you say?* said by a different native English speaker. The participants, having been instructed to do so, responded using the quote frame *I should say* and then repeated the phrase they had heard (e.g., *I should say, "We like the new pub."*). In CS, an English sentence was followed by the Czech prompt *Co jsi slyšel?* 'What did you hear?'. Participants responded by using the quote frame *Slyšel jsem_* ('I heard') and then switching back into English (e.g., *Slyšel jsem, "We like the new pub."*). In the IN condition, a Czech sentence, for example, *Pojďme do hospody* ('Let's go to a pub'), was followed by the English prompt *What should you say now?* (rather than a Czech prompt as in Š&P2015) and the participants responded by using the English quote frame *I should say* (rather than a Czech frame as in Š&P2015) and then translating the sentence they had heard from Czech into English (as they did in the earlier study). In all conditions, the 88 sentences were randomized uniquely for each participant. An example trial from each condition is given in Table 1.

Table 1. One trial in the delayed repetition and translation tasks for each language mode.

	Monolingual Mode: English-only Task	
stimulus (voice 1)	We like the new pub.	
prompt (voice 2)	What should you say?	
response	I should say, "We like the new pub."	
	Bilingual Mode	
	Code-Switching Task	**Interpreting Task**
stimulus (voice 1)	We like the new pub.	*Pojď'me do hospody.* [c]
prompt (voice 2)	*Co jsi slyšel?* [a]	What should you say now?
response	*Slyšel jsem,* [b] We like the new pub.	I should say, Let's go to a pub."

Glosses: [a] 'What did you hear?' [b] 'I heard,' [c] 'Let's go to a pub.'

3.2. Participants

Data were collected from 14 Czech students,[1] aged 21–24 (μ = 22), enrolled in the Bachelor programme "English for Interpreting and Translating" at Palacký University Olomouc (Olomouc, Czech Republic). It is a highly competitive study programme into which a limited number of students are admitted each year on the basis of a rigorous and comprehensive language examination that includes evaluation of oral skills. While the participants of the study were not screened for the degree of foreign accent, their English speech can be described as mildly foreign-accented. The minimum proficiency level at the entry into the programme is C1 (Verhelst et al. 2009). Nine were female, five were male. The participants were recruited from the final 3rd year and at the time of data collection had completed 5 semestrial interpreting courses, and thus had had a relatively extensive experience of performing in the bilingual mode, when both L1 and L2 are activated. None of the participants were fluent in another foreign language besides English.

A language experience questionnaire administered after the data collection confirmed that all participants learned English as a foreign language via formal instruction. Before reaching high-school age, they had no systematic exposure to authentic English input. Their language experience after the age of 15 was more diversified. At high school, some learners encountered individual native English teachers and/or spent a limited amount of time in an English-speaking environment; one participant had a year abroad experience in the US and five participants attended a bilingual high school. Participants' responses to the questionnaire are summarized in Table A1. At university, the participants had similar exposure to native English and attended the same semestrial course in English phonetics focused on listening and phonetic transcription of allophonic detail. The participants varied in their use of English in their private life.

Data were collected individually in a sound booth in two sessions, monolingual and bilingual (order counterbalanced across participants), separated by more than 48 h. The monolingual EN session was conducted exclusively in English by a Czech experimenter with a native-like English accent. The bilingual session consisted of the CS and IN conditions (order counterbalanced) separated by a 5-min break. A research assistant conducted the bilingual session in Czech. Stimuli were presented via Sennheiser HD 280 pro headphones (Sennheiser electronic GmbH & Co. KG, Wedemark, Germany).

[1] All participants gave their informed consent for inclusion before participating. The study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of Palacký University Olomouc (under the code UPOL-15519/290052018).

Recordings were made using a Zoom H4n digital recorder (Zoom Corporation, Tokyo, Japan) with a 44.1 kHz sampling rate and 16-bit quantization.

The bilinguals were assigned into long voice-lag and short voice-lag speaker groups (LongLag and ShortLag) according to their VOTs in the EN condition. The boundary was based on the VOT of the alveolar stop, found in the earlier study to show more variation than /p/. Mean VOTs of /t/ falling below 2 standard deviations (Birdsong 2005) of the native mean were considered short positive VOT. The numbers of participants in the two groups were 7 in each group. For the purpose of reanalysing the VOT data from Š&P2015, along with the present data, we regrouped speakers in the former study according to the VOT of /t/, which resulted in groups of 11 and 7 (LongLag and ShortLag respectively).

3.3. Analysis

The acoustic analysis of the current data was identical to the procedure used in Š&P2015 to ensure that the data are comparable. The first author and a research assistant used Praat (Boersma and Weenink 2014) to manually label boundaries of the target words, and of positive VOT intervals using constant criteria, based on Lisker and Abramson (1964). Subsequently, for each token of /p/ and /t/, a ratio of VOT duration to the duration of the respective target word was calculated, yielding a normalized VOT measure. This normalization was used to minimize the influence of speaking tempo on VOT (Kessinger and Blumstein 1998), which was expected to vary across individual speakers, the sentence positions, and the three elicitation conditions.

In order to examine the impact of the monolingual versus bilingual tasks on VOT, the relative, tempo-normalized VOT values of /p/ and /t/ were submitted to two separate Repeated Measures (RM) ANOVAs, with the between-subject variables Study (Š&P2015, Present Study) and Speaker group (LongLag, ShortLag), and the within-subject variable Condition (EN, CS, IN). In Š&P2015, the effect of sentence Position (target-word initial or final) was observed in the English-only condition as well as in the two bilingual-mode conditions. Since Position did not interact with Condition and its effect thus does not seem to be related to the language mode, Position was excluded as a factor from the new analysis and VOTs in sentence-initial and sentence-final words were averaged.

4. Results

4.1. The Monolingual English-Only Condition

Productions of /p/ and /t/ from the EN condition constituted baseline data against which bilingual mode effects were measured. Although in the subsequent analyses of dual-language versus single-language productions we used the normalized VOT values to factor out speech tempo variation, here we want to inform about the actual VOT values. In Table 2, for comparison with previous literature, absolute, not normalized, VOT values of /p/ and /t/ and standard deviations are shown for the two bilingual groups, LongLag and ShortLag, and the native speakers, separately for each stop in the sentence-initial and sentence-final target words and averaged across positions.

Table 2. Mean Voice Onset Time (VOT) of /p, t/ (in ms) produced by the bilingual speakers and native English speakers in the English-only condition in sentence-initial and sentence-final words.

	/p/						/t/					
	Initial		Final		Overall		Initial		Final		Overall	
	Mean	SD	Mean	SD	MEAN	SD	Mean	SD	Mean	SD	MEAN	SD
ShortLag	20.3	7.0	25.6	6.6	22.9	5.2	38.2	16.1	54.9	23.6	46.6	18.2
LongLag	44.9	13.2	57.2	15.3	51.1	10.9	62.1	12.7	82.0	14.7	72.0	11.1
Native Speaker	53.2	5.4	52.9	10.1	53.1	6.4	64.9	3.1	72.1	9.3	68.5	4.2

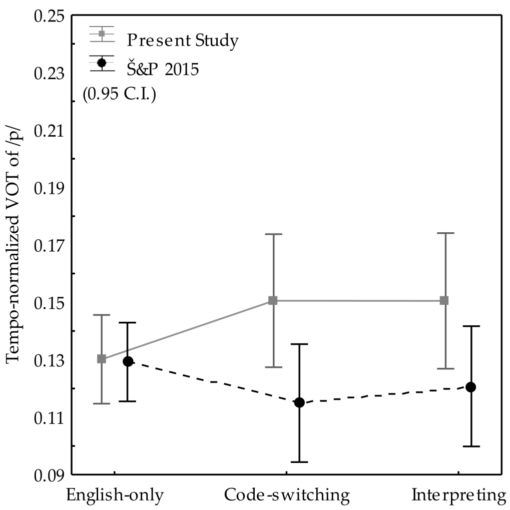
ShortLag: Speakers with short positive VOT; LongLag: Speakers with long positive VOT.

With respect to the place of articulation, longer VOT values had been expected for /t/ than for /p/ since it is articulated further back in the mouth (Lisker and Abramson 1964; Nearey and Rochet 1994). The Czech-English bilinguals in both groups produced a clear VOT distinction between the two place categories in both sentence positions. A Repeated Measure (RM) ANOVA performed on their mean VOT values with Speaker group as the between-subject variable and Place and Position as within-subject variables found the effect of Place to be significant, $F(1, 12) = 39.142$, $p < 0.0001$. Although there was a significant interaction with Position ($F(1, 12) = 8.4459$, $p < 0.05$), the post- hoc Tukey test confirmed the VOT of the labial stop to be significantly shorter than that of the alveolar stop both sentence-initially and sentence-finally. Unsurprisingly, the LongLag and ShortLag groups' mean VOT values were significantly different. A RM ANOVA performed on the tempo-normalized VOT with Place and Position as within-subject variables, still found a significant effect of Place ($F(1, 12) = 27.971$, $p < 0.001$) and a significant interaction Place with Position ($F(1, 8) = 30.432$, $p < 0.001$). Post-hoc Tukey test confirmed the normalized VOT of /p/ to be significantly smaller than that of /t/ in both sentence positions. In the subsequent analyses, RM ANOVAS were conducted for each voiceless stop separately.

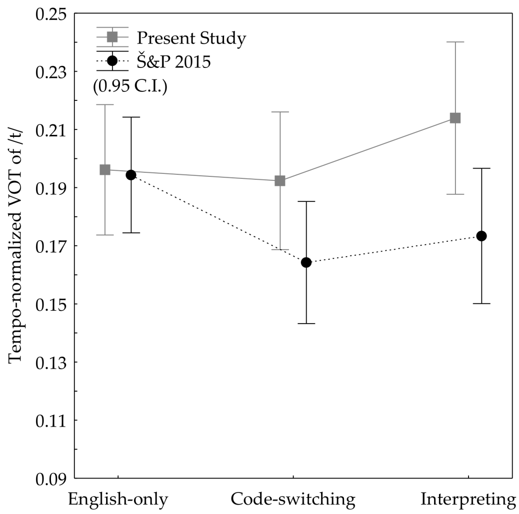
4.2. Bilinguals' Productions across Conditions

Next, we report the results of the two Repeated Measures ANOVA analyses conducted on the bilinguals' mean normalized VOTs of /p/ and /t/ with the between-subject variables Study (Š&P2015, Present Study) and Speaker group (LongLag, ShortLag), and the within-subject variable Condition (EN, CS, IN).

For the normalized VOT of /p/, the expected main effect of Speaker Group was observed ($F(1, 28) = 54.645$, $p < 0.001$), while there was no effect of the other between-subject factor, that is, Study. Condition alone did not significantly affect VOT either. However, there was a significant interaction between Condition and Study ($F(2, 56) = 5.0139$, $p < 0.01$), as can be seen in Figure 1a. No significant pairwise differences between the VOTs of /p/ in either condition and study were found by post-hoc Tukey tests.



(**a**)



(**b**)

Figure 1. Mean Normalized Voice Onset Time (VOT) values produced by the bilinguals in Šimáčková and Podlipský (2015) (in the figure, Š&P2015) and the Present Study during the English-only, Code-switching, and Interpreting tasks (**a**) the bilabial voiceless stop; (**b**) the alveolar voiceless stop.

A parallel RM ANOVA on normalized VOT of /t/ also found a main effect of Speaker Group ($F(1, 28) = 8.1744$, $p < 0.01$) and no effect of Study. However, there was a main effect of Condition ($F(2, 56) = 4.5370$, $p < 0.05$), a post-hoc Tukey test confirming the normalized VOT of /t/ to be the lowest during code-switching: the CS-EN difference was significant ($p < 0.05$), the CS-IN marginally exceeded significance ($p = 0.061$); for the EN and IN conditions no difference was found. Again, there was a significant interaction between Condition and Study ($F(2, 56) = 5.0797$, $p < 0.01$), as apparent in Figure 1b. The only significant difference between conditions within each study (Tukey) was the smaller normalized VOT of /t/ in the CS condition in Š&P2015 than in the EN condition in that study. Without significant pairwise differences, the observed VOT patterns can at best be described as trends. As seen in Figure 1, in the L2-only condition the VOT values from Š&P2015 were comparable to those from the present study for both /p/ and /t/. In the interpreting condition, the new participants from the present study had longer mean VOT than the speakers in Š&P2015 (whose interpreting task also involved a code-switch). However, we cannot conclude that L1-interference was reduced as result of the removal of the code-switch from the interpreting task. This is because speakers in the present study tended to have higher VOTs even in the code-switching condition. In fact, unlike in the original study, the VOTs in the bilingual tasks in the follow-up tended to be longer than in the L2-only condition, yielding the Study × Condition interactions.

Individual differences in how the two bilingual conditions influenced speakers' production of VOT can be observed in Figure 2. The vertical axis shows the difference of each speaker's mean normalized VOTs during code-switching (top) and interpreting (bottom) from their baseline VOT values in the L2-only condition. The speakers are arranged horizontally from those with the lowest to those with highest mean VOT in the L2-only condition. In Š&P2015 (the left charts), bilinguals with longer more L2-like baseline VOTs tended to shorten them in the bilingual tasks, unlike speakers whose VOTs in the baseline single-language condition (EN) were short, L1-like, to begin with. In the follow-up study (the right plots) though, this was not the case, and many speakers in fact significantly lengthened rather than shortened their VOTs in the bilingual task, that is, made them less L1-like.

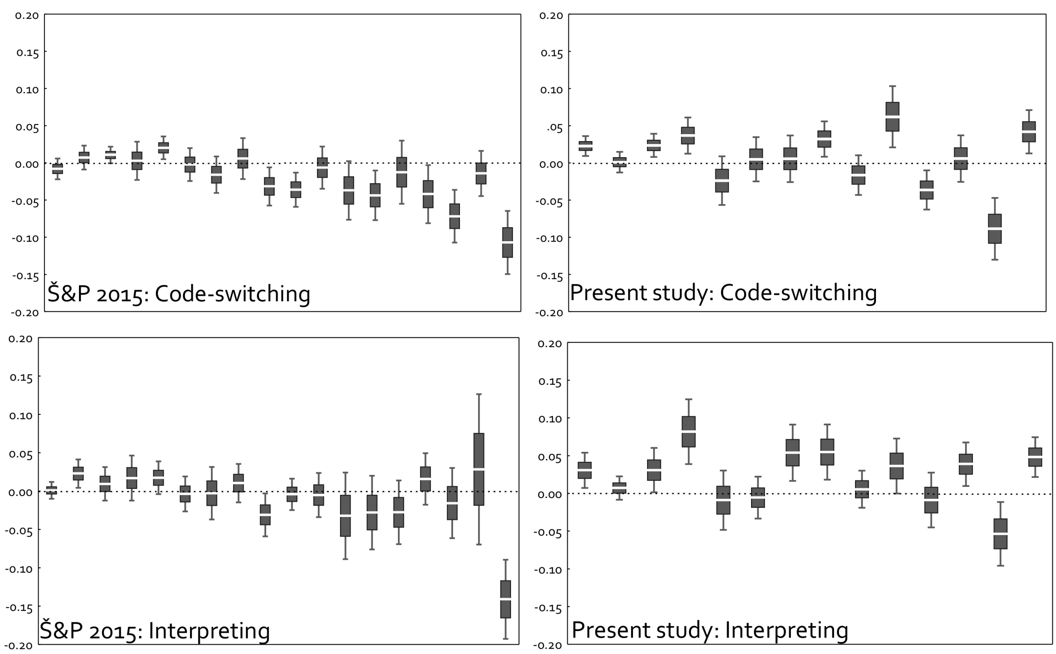


Figure 2. Difference from normalized VOT in the English-only condition: individual speaker's means, confidence intervals, and standard errors. Within each plot, the speakers are arranged from those with the lowest (**left**) to those with the highest (**right**) mean normalized VOT. Data from Š&P 2015 and the present study.

5. Discussion

Considering long-term cross-language interference first, the data collected for this study confirm our earlier observation that some late L1-dominant (though advanced) Czech learners of English can learn to produce L2 voiceless stops in a native-like way (Šimáčková and Podlipský 2015), despite the fact that such a feat is usually reported for early bilinguals (e.g., Antoniou et al. 2010) while there are numerous reports of late L2 learners typically producing intermediate VOT (e.g., Caramazza et al. 1973; Flege 1987). When speaking in the monolingual English mode, half of our 14 L1-Czech L2-English bilinguals (whom we labelled LongLag) produced average VOT values within our reference native speakers' range. The other half (ShortLag) produced /p/ with VOT typical for Czech—a short-lag language (Lisker and Abramson 1964)—and /t/ with intermediate VOT values, longer than in Czech.

The first goal in the present study was to replicate the effect of bilingual mode on L2 VOT production found for highly proficient foreign language learners in Šimáčková and Podlipský (2015). In that study, the three production tasks required the bilinguals either (i) to report in L2 what they had just heard in L2; or (ii) to start an utterance in L1 and switch into L2 to report what they had heard in L2; or (iii) to start an utterance in L1 and switch into L2 to report what they had heard in L1. Alternating between L1 and L2 in the two latter tasks led to a short-term increase in L1-to-L2 phonetic interference, which is in line with several previous studies (e.g., Bullock and Toribio 2009; Antoniou et al. 2011). In the present follow-up study, the last task was altered by removing the code-switch, hence the bilinguals, after reacting in L2 to an L2 prompt, simply translated into L2 what they had heard in L1.

Although the follow-up study reported here was run as closely as possible to the original study, it failed to replicate the phonetic effect of language mode. No shortening of English VOT was observed either in the bilinguals' code-switched or in the translated utterances, even in speakers with longer, more L2-like baseline VOTs. In fact, for some participants, their L2-English VOT was extended in the bilingual tasks, becoming less like the VOT of Czech, their L1. To decide whether such an increase is systematic for the bilinguals in this population requires more data collection. If it is, the divergence, that is, temporary enhancement of an L2 phonetic category, could be due to monitoring (Green and Wei 2014). Self-monitoring that blocks phonetic sliding towards L1 (e.g., towards L1 VOT settings) might be more likely when a code-switch is motivated externally rather than internally, that is, when the speaker is instructed when to switch, and when the switching takes place at a clearly defined structural boundary (at the end of a quote frame and the beginning of quoted speech).

Our second question in the present study was whether phonetic interference in L2 speech changes dynamically even without very recent articulation of L1 sounds, namely due to a global effect of dual language activation during a task that explicitly forces the use of two languages simultaneously. In Šimáčková and Podlipský (2015), phonetic interference increased in the bilingual mode for most speakers with more L2-like VOTs while the two bilingual tasks, code-switching and interpreting did not differ from each other in mean VOT. Thus, no cumulative effect was observed due to combining code-switching with online translating. In the present study, we asked whether short-term interference would still be observed during the interpreting condition even when actual articulation in L1 was removed from the task, that is, as a result of continuous activation of L1 via perceiving and decoding the stimuli to be translated into L2. Since the present study did not see a difference between the monolingual task and either interpreting or code-switching, our second research question cannot be answered. The only significant difference we found between the conditions—the shorter VOT of /t/ in the code-switching condition compared to the English-only and Interpreting conditions—suggesting that actual articulation might be necessary for interference producing L1–L2 convergence, does not allow us to answer this question with confidence.

Let us now consider why the current follow-up did not replicate our previous study. We can think of a number of potential reasons for the differences between Šimáčková and Podlipský (2015) and the present study observed in the bilingual tasks. One possible explanation is that we might have overestimated the homogeneity of the foreign language learner population from which the participants were recruited, the disparity in the participants' L2 pronunciation abilities being greater than assumed despite the lack of a difference between them in the L2-only task. Consequently, the participants from Šimáčková and Podlipský (2015) may not have been matched well for their baseline VOTs with those from the present study. The higher VOTs that the participants of the present study produced in the bilingual tasks, as compared to the L2-only task, would then reflect their actual baseline L2 VOT. We cannot exclude this explanation but do not find it likely. Alternatively, it is possible that the amount of data we collected for each bilingual was not representative enough of that speaker, and yet again, the VOT distributions measured in the monolingual condition in both studies were very similar. Therefore, we think that neither of these interpretations explains why the present study did not replicate the original finding.

Instead, it seems there are differences between bilinguals in how their L2 pronunciation is affected by the demands of the bilingual tasks. Some show a short-term L1 interference, such as our speakers in Šimáčková and Podlipský (2015) (and such as the L1 Greek speakers of L2 English in Antoniou et al. (2011)). Others, however, may strive to maintain a clearer phonetic distinction between their languages due to using both of them during a single utterance, and hence temporarily enhance the distinctiveness of L2 sounds from the corresponding L1 categories. This appears to have been the case for the L1 English speakers of L2 Spanish in (Bullock and Toribio 2009) and possibly also for our speakers in the present study. Still others may vary between these two types of response, while some may not be affected at all. In a study with a larger number of participants it might be possible to demonstrate whether one of these patterns is more common among highly proficient foreign language speakers.

It has been repeatedly noted that phonetic studies of code-switching produce variable results, for example, in Balukas and Koops (2014); Bullock and Toribio (2009); Olson (2013); and Piccinini and Arvaniti (2015). This has been attributed, at least partially, to the diversity of the bilingual populations studied. Undoubtedly, the direction and magnitude of inter-language interaction depends on the pattern of L1 and L2 acquisition and use, and the resulting language proficiency and dominance of a bilingual. Our data obtained from bilinguals drawn from one relatively homogeneous bilingual population suggests that, in addition to the language-background differences, individual code-switching strategies may contribute to the disparate outcomes of searching for phonetic effects of code-switching. Some speakers may have better control of their L2 production at the point of and after the switch. In fact, as proposed above, they may even over-compensate for the differences between Czech and English in the production of VOT and implement a phonetic shift away from the L1 articulatory norm. Future research into phonetic consequences of speaking in the bilingual mode should be directed at differences between individual bilinguals, such as differences in self-monitoring.

Author Contributions: Š.Š. designed the experiment, prepared the instrument and collected the data. Š.Š. also wrote the literature review and drafted the first version of the paper with valuable input from V.J.P. Both authors contributed equally to the analysis of the data and collaborated on the revised version of the paper.

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Appendix A

Table A1. Language experience questionnaire: Learner number (No), age at the onset of learning (AOL); age at which learner felt comfortable in L2; learning experience at elementary school age and high school age (extended English language instruction (Ext. Eng. Instr.), contact with a native English teacher, time spent in an English-speaking country); current minimum estimated exposure to English in media.

			Elementary School Age			High School Age			
No	**AOL**	**Comfort Age in L2**	**Ext. Eng. Instr.**	**Native Eng. Teacher**	**Time Abroad**	**Ext. Eng. Instr.**	**Native Eng. Teacher**	**Time Abroad**	**Current L2 Media Exposure**
1	9	15	Yes	No	No	Yes	Yes	No	min. 2 h/day
2	15	21	Yes	No	No	No	Yes	No	min. 2 h/month
3	9	15	No	No	No	Yes	Yes	No	min. 1 h/week
4	10	17	No	No	No	No	No	12 months	min. 1 h/day
5	10	17	No	No	2 months	Yes	Yes	2 months	min. 1 h/day
6	8	16	No	No	No	No	No	No	min. 3 h/day
7	10	15	Yes	No	No	Yes	Yes	No	min. 3 h/day
8	10	14	Yes	No	1 month	No	No	3 months	min. 2 h/day
9	7	15	Yes	No	No	No	Yes	3 months	min. 3 h/day
10	8	11	No	No	No	No	No	No	min. 3 h/day
11	7	15	Yes	No	No	Yes	Yes	No	min. 5 h/month
12	10	17	No	No	No	No	No	No	min. 2 h/day
13	9	17	No	No	No	No	No	No	min. 3 h/day
14	9	16	No	No	No	No	No	No	min. 3 h/week

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