Inter-language interference in VOT production by L2-dominant bilinguals: Asymmetries in phonetic code-switching

Interlanguage effects in bilingual code-switching have been noted at higher levels of language use such as time-cost in language comprehension, word recognition, and reading speed, but have not been adequately investigated at the level of phonetic realisation. While contextual changes in bilinguals' language usage, such as prolonged stays overseas, are known to result in first language (L1) and second language (L2) phonetic shifts (Sancier & Fowler, 1997), code-switching provides a unique opportunity for observing the immediate phonetic effects of interlanguage interaction. We applied a code-switching manipulation as a novel and sensitive test that differentiates among four competing hypotheses of L1-L2 phonetic interaction: 1) that there is no L1-L2 interaction, as bilinguals switch languages completely, free of interlanguage phonetic interference (Grosjean & Miller, 1994); 2) Bidirectional L1-L2 interaction will result in productions whose phonetic details differ from those of unilingual mode (in which only one language is used) for both the L1 and L2, compatible with the notion of a common L1-L2 acoustic-phonetic space (SLM: Flege, 1995; gestural drift: Fowler, Sramko, Ostry, Rowland, & Hallé, 2008; Sancier & Fowler, 1997); 3) The L1 will exert persistent unidirectional interference on productions in the L2 (Caramazza, Yeni-Komshian, Zurif, & Carbone, 1973), despite many years of usage of, and even dominance in, the L2; and 4) Dominance in the L2 will exert a unidirectional influence on the L1, as the influence of the L1 on the L2 will be suppressed, but the dominant L2 will influence the code-switched productions in the nondominant L1 (see Flege, Mackay, & Piske, 2002).

We selected voice onset time (VOT) as our measure of phonetic interference, as it is the measure that has been reported in the great majority of past research on this topic, and allows for direct within-subjects comparison with our own work (Antoniou, Best, Tyler, & Kroos, under review), and cross-subject comparisons with other directly relevant research. In addition, our target languages, Greek and English, differ in the phonetic settings of their stop-voicing distinctions: Greek contrasts stops with voicing lead versus short-lag VOT (Botinis, Fourakis, & Prinou, 2000), whereas English has a short-lag unaspirated versus long-lag aspirated VOT distinction. Importantly for the current experiment, Greek and English differ not only in their phonetic settings for stop-voicing distinctions, but in their orthographies as well. This difference in orthography should indicate unequivocally to the speakers exactly where a code-switch is to occur in visually-presented stimulus sentences, thus serving as a constant reminder of the switch in language for the target item.

We measured the VOTs of early, L2-dominant Greek–English bilinguals' productions of the bilabial and coronal stops /b, d, p, t/ in initial position. In the first session, targets were produced in a unilingual Greek (L1) or English (L2) mode (separate groups, n = 8 in each group), and in a later session, the same L1 or L2 targets were produced by the same speaker in a carrier sentence from the other language (i.e., as a code-switch) using orthography to signal the target language change. Mean VOTs and standard deviations are presented in Table 1.

Table 1. *Bilinguals' mean VOTs (M) and standard deviations (SD) of Greek and English stops in unilingual mode and when code-switching from the base language.*

Language Mode	ba		da		pa		ta	
	M	*SD*	*M*	*SD*	*M*	*SD*	*M*	*SD*
Greek targets group								
Unilingual mode	**-117.9**	27.1	**-122.1**	30.3	**12.4**	2.4	**15.3**	6.5
Code-switch	**-111.4**	52.7	**-108.7**	46.0	**23.7**	33.6	**25.0**	16.1
English targets group								
Unilingual mode	**-8.4**	23.6	**9.0**	21.1	**76.1**	19.3	**91.9**	19.9
Code-switch	**-37.8**	52.6	**-55.0**	45.5	**68.6**	24.4	**81.8**	15.9

We conducted a 2 × (2 × 2 × 2) analysis of variance with the between-subjects factor of target language (Greek vs. English), and within-subjects factors of recording session (unilingual mode vs. code-switch), target voicing (voiced vs. voiceless), and place (bilabial vs. coronal). A significant main effect of target language, $F(1, 14) = 77.6$, $p < .001$, $\eta_p^2 = .847$, confirmed the expected language-specific VOT differences between Greek (negative mean VOT due to long lead of voiced stops) and English (positive mean VOT due to long lag of voiceless stops) (M_{GREEK} = -48.0 ms; $M_{ENGLISH}$ = 28.3 ms). A significant main effect of voicing, $F(1, 14) = 548.2$, $p < .001$, $\eta_p^2 = .975$, and Target Language × Voicing interaction, $F(1, 14) = 9.7$, $p = .008$, $\eta_p^2 = .408$, showed that the overall VOT difference between voiced and voiceless stops was greater in Greek than in English (Greek: M_{VOICED} = -115.0 ms, $M_{VOICELESS}$ = 19.1 ms; English: M_{VOICED} = -18.6 ms, $M_{VOICELESS}$ = 79.6 ms).

Importantly, a significant Target Language × Recording Session interaction, $F(1, 14) = 10.8$, $p = .005$, $\eta_p^2 = .436$, revealed that the mean VOT shift between the unilingual mode and code-switched recordings, collapsed across voicing, was greater for the English targets than the Greek targets ($Mdiff_{GREEK}$ = -10.2 ms; $Mdiff_{ENGLISH}$ = 27.8 ms). Simple effects tests on this interaction showed that English VOTs became more Greek-like (i.e., voiced stops had more lead VOT, and voiceless stops had shorter lag) in the code-switch recordings, $F(1, 14) = 11.6$, $p = .004$, whereas Greek VOTs were unaffected by recording session, *ns*.

In unilingual mode, bilinguals produced monolingual-like VOTs both in Greek and English (Antoniou et al., under review). However, when asked to produce the identical targets via a code-switch, English stops produced via a code-switch from Greek had significantly shorter (more Greek-like) VOTs than those in unilingual English mode (see Figure 1) (inconsistent with hypothesis 1). In contrast, code-switched Greek targets from within English mode failed to show a reliable shift toward English VOTs (thus, hypothesis 2 is not well supported). It appears that L2 dominance does not guard against an L1 influence on production of the L2 (refuting hypothesis 4). In fact, the asymmetrical effect we observed suggests a pervasive L1 influence even in L2-dominant bilinguals (consistent with hypothesis 3), and this is observed most clearly under the specifically inter-language condition of code-switching.

These findings demonstrate that the L1 interferes with the L2 in production, even following years of L2-dominant experience in an L2-immersion environment. An important and novel contribution of our study is that this L1-interference was induced by our deliberate code-switching manipulation. We have demonstrated that code-

switching may result in unidirectional L1-interference on production of L2 segments. This L1-interference was observed despite many years of L2 immersion and dominance since early childhood, consistent with the persistent L1-effects on L2-perception reported by Sebastián-Gallés and colleagues (e.g., Pallier, Colome, & Sebastian-Galles, 2001; Sebastian-Galles, Echeverria, & Bosch, 2005; Sebastian-Galles & Soto-Faraco, 1999).

The results of this study provide the first clear evidence that code-switching can have an effect on the phonetic realisation of bilinguals' production of speech. This is consistent with past research on higher levels of language use, which has found that code-switching shows a base language effect, or processing cost (Altarriba, Kroll, Sholl, & Rayner, 1996; Grosjean, 1988; Kolers, 1966; Li, 1996; Macnamara & Kushnir, 1971). Code-switching shows an analogous base language (L1) effect at the phonetic level in speech production as well, and thus is a sensitive test of L1-L2 phonetic interference as well as asymmetries in direction.

Our findings suggest that future research should attend more to order of acquisition asymmetries. For instance, if L2-dominant bilinguals show L1 effects on their L2, we would expect L1-dominant bilinguals to show even stronger L1-interference when code-switching. We also recommend examining voiced stops in gestural drift studies, in addition to voiceless stops, as L1-interference was more prevalent in the longer lead VOTs of the English (L2) voiced stops than in voiceless stops.

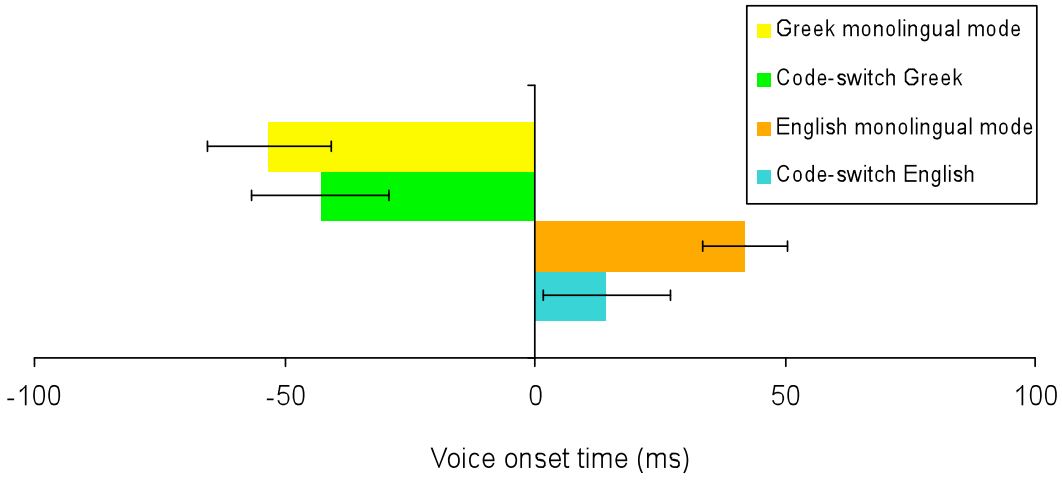

Figure 1. Bilinguals' mean VOTs in Greek and English initial-position stops across voiced and voiceless targets produced in unilingual modes and from code-switches.

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