



Research Article

Phonetic drift in Spanish-English bilinguals: Experiment and a self-organizing model

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ABSTRACT

Studies of speech accommodation provide evidence for change in use of language structures beyond the critical/sensitive period. For example, Sancier and Fowler (1997) found changes in the voice-onset-times (VOTs) of both languages of a Portuguese-English bilingual as a function of her language context. Though accommodation has been studied widely within a monolingual context, it has received less attention in and between the languages of bilinguals. We tested whether these findings of phonetic accommodation, speech accommodation at the phonetic level, would generalize to a sample of Spanish-English bilinguals. We recorded participants reading Spanish and English sentences after 3–4 months in the US and after 2–4 weeks in a Spanish speaking country and measured the VOTs of their voiceless plosives. Our statistical analyses show that participants' English VOTs drifted towards those of the ambient language, but their Spanish VOTs did not. We found considerable variation in the extent of individual participants' drift in English. Further analysis of our results suggested that native-likeness of L2 VOTs and extent of active language use predict the extent of drift. We provide a model based on principles of self-organizing dynamical systems to account for our Spanish-English phonetic drift findings and the Portuguese-English findings.

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1. Introduction

When language users speak with one another, whether they are native speakers of the same language (Pardo, 2006), of different varieties of a language (Babel, 2010; Kim, Horton, & Bradlow, 2011), different dialects (Pardo, 2013) or of different languages altogether (Sancier & Fowler, 1997), adaptation takes place at every level of language (Bock, 1986; Dunstan, 2010; Hohenstein, Eisenberg, & Naigles, 2006; Liberman, 2012). For example, Pardo (2006), found that the speech of native speakers of American English became more similar during conversational interaction, as measured by listeners' judgments. Babel (2010) showed convergence of vowel quality of New Zealand English speakers towards those of Australian

English speakers in a word repetition task. Sancier and Fowler (1997) found that the voiceless-stop voice onset times (VOTs) of a Portuguese-English bilingual converged to those of the ambient language as the speaker traveled between Brazil and the U.S. Likewise, it has been shown that syntactic (Bock, 1986), morphological (Dunstan, 2010), and semantic (Liberman, 2012) structures present in a speaker-hearer's ambient language influence subsequent language use.

These findings are interesting because the adaptations are often subcategorical or involve a change in the frequency of usage of a particular construction. Adaptations of this kind cannot be fully accounted for by a system based purely on discrete categories (Chomsky & Halle, 1968; McCarthy, 2003). They are better explained on the basis of *continuous* adaptation (Roon & Gafos, 2015; Spivey, Grosjean, & Knoblich, 2005). Additionally, it has been claimed that speaker-hearers are not able to acquire a second language (L2) authentically beyond the end of a critical or sensitive period (Lenneberg, 1967). Findings of ongoing modification of linguistic units over the course of spoken interactions suggest that these units and

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the speaker-hearers who exchange them have a degree of flexibility that the critical period hypothesis does not account for, which raises questions about how well the sensitive period claim generalizes across different language learners, as well as the factors underlying observed age-related declines in language-learning success (Flege, 1987b; Flege, Yeni-Komshian, & Liu, 1999; Krashen, 1975; Muñoz & Singleton, 2011). These observations motivate us to consider additional factors to explain between-speaker differences and to propose a dynamic approach to account for patterns of phonetic accommodation.

We briefly summarize a selection of studies focused on the phonetic level of this broad area of research, beginning with the more short-term and passive manipulations and leading to the more long-term and interactive ones, with the aim of identifying manipulations most likely to yield measurable accommodation. We then describe an investigation of learning at the phonetic level in bilingual speakers who spend weeks or months alternately in a predominantly L1 or L2 language community.

There is considerable variation in terminology applied to the kind of phonetic change we review and report here. Choice of terminology depends on whether the primary focus of the investigators is within or between languages, a first language (L1) or a second language (L2), and spontaneous or intentional imitation, among other factors (Tobin, 2015). For clarity, we define our terms here. We use the term *speech accommodation* (cf. Bourhis & Giles, 1977) to refer very broadly to these perceptually guided changes in speech production at any level of spoken language, whether within or between a speaker's languages. We use the term *phonetic accommodation* (or simply *accommodation*, because the phonetic level is our primary focus) to refer generally to speech accommodation at the phonetic level, whether within or between languages. In the case of people who travel back and forth between language environments, effects are more appropriately attributed to changes in ambient language rather than to the unique impact of one ambient language or another, rendering moot the question of within- vs. between-language effects. When relevant, we use the term *phonetic drift* to refer specifically to the subset of these findings that demonstrate cross-language effects of phonetic accommodation, that is, effects of exposure to an ambient language on another language that a speaker-hearer is familiar with but is not using at the time of exposure. However, we still use the terms *convergence* and *divergence* to denote the direction of an effect, irrespective of the language(s) involved in the effect. Both in monolingual, within-language contexts, and in between-language contexts, these terms refer to adaptation of a speaker's phones *towards* or *away from* those of interlocutors, or model speakers. The bilingual, between-language context, however, has the additional complexity that both L1 and L2 phones may converge towards or diverge from those of interlocutors or model speakers.

We begin with a study by Nielsen (2011), which illustrates the basic finding of within-language phonetic accommodation. She investigated whether speakers' VOTs in [p]-initial words would accommodate after hearing artificially shortened or lengthened VOTs in words of their native language, American English. She found that they did, that this accommodation generalized to new [p]-initial words that speakers had not heard,

and to a novel place of articulation, [k]. However, her participants only converged to longer VOTs, not to shorter ones, perhaps because the latter accommodation pattern could affect the voiced-voiceless category boundary.

The authors of two different investigations of code switching, in which speakers change rapidly from one language to another within a single utterance, report reliable drift of Spanish-English and Greek-English bilingual participants' English VOTs towards Spanish (Bullock & Toribio, 2009) and Greek (Antonioni, Best, Tyler, & Kroos, 2011) VOT, respectively.¹ Evidence for convergence of the L1 VOTs towards English VOT, on the other hand, was much less reliable. Among the Spanish speakers, convergence was only observed in the early Spanish-English bilingual group ($n = 8$). Among the Greek speakers ($n = 16$) no convergence of Greek VOT towards English VOT was observed at all.

Likewise, investigations of word shadowing have produced a variety of findings of accommodation. For example, Babel (2012) reported that participants who rated images of a speaker as attractive converged towards the speaker in vowel quality when they shadowed words ostensibly produced by the speaker more than participants who rated the speaker as less attractive. Goldinger (1998) found that greater immediacy of shadowing, higher numbers of instances of shadowing the same word token, and lower frequency of shadowed words yielded greater accommodation as judged by listeners in a holistic word-similarity judgment task.

Using a more naturalistic task than shadowing, in which one member in each pair of interlocutors described a route across a map while the other tried to draw the route, Pardo (2006) observed the effects of a variety of social and conversational factors on phonetic accommodation in American English over the time scale of a conversational interaction. She found that interlocutors' vowel quality converged, as quantified in vowel $F1 \times F2$ space. In a perceptual and acoustic follow-up study using the same map task (Pardo, 2010), she found that a significant portion of the variance in similarity judgments of listeners who judged the words the speakers had produced, could be attributed to word duration and to the female participants. That is, words spoken by participants were more likely to be judged similar to the model's speech if words were longer and if participants were female. The investigation also showed that not all phonetic segments or other aspects of speech accommodate to the same extent; for example, high vowels accommodated more than low vowels. It also showed that accommodation in these different segments is also not necessarily equally perceptible, and that it is possible to observe both convergence and divergence within the same conversation (high vowels converged, while low vowels diverged).

Kim et al. (2011) extended Pardo's study by manipulating the language "distance" between members of participant pairs. Pair members shared or differed in dialect or in native language. Using a task in which interlocutors had to identify differences in two versions of a depicted scene through conversation, they found bidirectional convergence between same-dialect interlocutors of a common L1, but no clear evidence for accommodation between different-dialect interlocutors or different-L1 interlocutors. Although it is possible that

¹ Both Spanish and Greek, compared to English, have short-lag voiceless VOTs.

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