



Research Article

Perceptual categorization and bilingual language modes: Assessing the *double phonemic boundary* in early and late bilinguals [☆]

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ABSTRACT

In the present study, Spanish-English bilinguals' perceptual boundaries between voiced and voiceless stops (*a* / *b* / *-p* / continuum including pre-voiced, voiceless unaspirated, and voiceless aspirated tokens) are shown to be modulated by whether participants are "led to believe" they are classifying Spanish or English sounds. In Experiment 1, simultaneous Spanish-English bilinguals and beginner second-language learners of Spanish labeled the same acoustic continuum in two experimental sessions (Spanish mode, English mode), and both groups were found to display language-specific perceptual boundaries (or session effects). In Experiment 2, early bilinguals and late second-language learners of various levels of proficiency participated in a single session in which, in random order, they labeled nonwords that were designed to prime either Spanish or English language modes. Early bilinguals and relatively proficient second-language learners, but not less proficient learners, displayed mode-specific perceptual normalization criteria even in conditions of rapid, random mode switching. Along with similar ones, the experiments reported here demonstrate that bilinguals are able to exploit language-specific perceptual processes (or norms) when processing speech sounds, which entails some degree of separation between their sound systems.

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1. Introduction

People who speak two languages often pronounce and perceive speech sounds differently from those who speak one language. For instance, a bilingual speaker of English and French is likely to produce and perceive the sounds of both English and French differently from how monolingual speakers of either English or French produce and perceive such sounds (Flege, 1987b; Fowler, Sramko, Ostry, Rowland, & Hallé, 2008, among many others). This seems true of simultaneous,

early, and late bilinguals, but such differences are particularly noticeable in bilinguals who learned their second language as adults rather than as children (Caramazza, Yeni-Komshian, Zurif, & Carbone, 1973; Flege, 1987a; Flege & Hillenbrand, 1984; Fowler et al., 2008; Oyama, 1976; Pallier, Bosch, & Sebastián-Gallés, 1997; Piske, MacKay, & Flege, 2001; Sundara & Polka, 2008). The extant evidence suggests that the differences in phonetic behavior between bilingual and monolingual speakers are most importantly due to the fact that, sharing a common representational network, bilinguals' first- and second-language sounds interact (Best & Tyler, 2007; Flege, 1995, 2007; Simonet, 2016; Van Leussen & Escudero, 2015).

While the evidence in favor of cross-linguistic interaction in bilinguals is robust, it is still the case that bilinguals are not prevented from using language-specific sounds in a language-specific manner. For instance, /*p*/ is pronounced differently in French than it is in English—among other things, English /*p*/ is aspirated and French /*p*/ is not—and this difference is typically observed in bilingual, as well as in monolingual, speech. Caramazza et al. (1973), to cite one example, showed that early French-English bilinguals produced aspirated /*p*/ in their

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English productions, but not in their French productions (see also Antoniou, Best, Tyler, & Kroos, 2010; Magloire & Green, 1999; Olson, 2013). Moreover, adult second-language learners can form new phonetic categories specific to their second language. This does not mean that, in the bilingual mind, language-specific phonetic categories are truly independent from each other. Fowler et al. (2008) reported that, in the productions of French-English bilinguals, the length of the aspiration period of English /p/ was shorter than it was in the productions of English monolinguals (see also Flege, 1987b; Flege & Hillenbrand, 1984). In other words, bilinguals seem to be able to limit the production of language-specific sounds to the appropriate language, but this does not impede cross-linguistic interactions, which often take the form of low-level phonetic convergence across languages.

The broad research questions that motivate the present study are as follows: Bilinguals have been found to manifest language-specific production patterns (at least to some extent), but do they also demonstrate language-specific perceptual routines? In other words, do bilinguals have separate perceptual categorization habits for the sounds of their two languages? In this study, we report on two experiments in which early and late Spanish-English bilinguals were asked to categorize a /b-/p/ acoustic continuum under two experimental conditions, one in which they were led to believe they were listening to Spanish sounds and one in which they were led to believe they were listening to English sounds. We operationalize the questions above with the following, narrower questions: Do our experimental settings, which are designed to prime language-specific processing modes in bilinguals, modulate the way bilingual listeners classify an acoustic /b-/p/ continuum? And does bilingual language experience (early vs. late bilingualism, and linguistic proficiency) interact with experimental settings effects (if any)?

1.1. Review of the literature

The present study is particularly concerned with how Spanish-English bilinguals categorize English and Spanish voiced and voiceless bilabial stops, /b/ and /p/ (García-Sierra, Diehl, & Champlin, 2009; Gonzales & Lotto, 2013; Williams, 1977). In English (in utterance-initial position), both /b/ and /p/ are voiceless—typically, there is no voicing during closure—but, while /p/ is aspirated, /b/ is not. Thus, in English, the difference between /b/ and /p/ depends on aspiration, [p]–[p^h] (Beckman, Jessen, & Ringen, 2013; Iverson & Salmons, 1995; Lisker & Abramson, 1964). In Spanish (in utterance-initial position), both /b/ and /p/ are unaspirated but, while /p/ is voiceless, /b/ is voiced—voicing begins during the closure in /b/ but not /p/. Thus, in Spanish, the difference between /b/ and /p/ is one of “true” voicing, [b]–[p] (Abramson & Lisker, 1972; Kirby & Ladd, 2016; Lisker & Abramson, 1964; Rosner, López-Bascuas, García-Albea, & Fahey, 2000). This asymmetry leads to the following scenario: A Spanish speaker is likely to perceptually categorize an unaspirated, voiceless bilabial stop, [p], as /p/ while an English speaker is likely to categorize it as /b/ (Elman, Diehl, & Buchwald, 1977). In other words, the perceptual (phonemic) boundary between /b/ and /p/ varies as a function of the language spoken by the listener because the phonetic implementation of these phonemes—but

perhaps also their phonological composition (Beckman et al., 2013; Iverson & Salmons, 1995)—is language specific.

What about Spanish-English bilinguals? The hypothesis we explore in the present study is that, in bilinguals, *perceptual categorization depends on language modes*. The term *language modes* refers to the state of activation of the bilingual’s languages (and their processing mechanisms) at a given point in time (Grosjean, 1985, 1989, 1998a, 1998b). According to Grosjean (1985), mode activation is determined by psychosocial and linguistic factors modulated by the communicative context of an interaction. For instance, a Spanish-English bilingual may be in Spanish unilingual mode when the interlocutor or the situation requires that only Spanish be used, whereas she may be in English unilingual mode when the situation requires that only English be used. In particular, the hypothesis is that, when in Spanish mode, Spanish-English bilinguals are more likely to categorize [p] as phonemically voiceless while, when in English mode, they are more likely to do so as phonemically voiced.

Exploring the perceptual routines of bilinguals and their potential interaction with language modes is not a recent trend. The first study about this investigated a sample of early, proficient French-English bilinguals from Québec, Canada (Caramazza et al., 1973; Caramazza, Yeni-Komshian, & Zurif, 1974). In one session, participants were placed in French mode by talking to them in French before the experiment, giving them experimental instructions in French, and asking them to pronounce a set of French materials. In another session, they were placed in English mode by talking to them in English, providing them instructions in English, and asking them to produce a list of English materials. Importantly, participants were asked to categorize the same acoustic /b-/p/ continuum in the two experimental sessions—the stimuli varied as a function of the shape and length of their voice onset times (VOT) and included pre-voiced, voiceless unaspirated, and voiceless aspirated tokens (Abramson & Lisker, 1972; Lisker & Abramson, 1964). The hypothesis was that, if language modes facilitate the activation of language-specific perceptual strategies, the same acoustic continuum would be categorized differently as a function of the experimental session. Interestingly, bilinguals’ classification patterns were found to be unaffected by language modes. Williams (1977), who replicated the studies of Caramazza and colleagues with a sample of Spanish-English bilinguals recruited in the United States, also produced null results. Williams, however, acknowledged that this “finding does not constitute proof that a language-specific set does not influence the perception of speech. It only indicates that the conditions of this experiment do not elicit such an effect” (Williams, 1977, p. 295). Since then, researchers have focused their effort on creating (and understanding) the conditions that (might) elicit this effect. Three subsequent studies were successful in doing so (Elman et al., 1977; Flege & Eefting, 1987; Hazan & Boulakia, 1993).

Elman et al. (1977) observed two limitations with the methodology of past studies. First, auditory stimuli were synthetic, which may have encouraged listeners to fall back on a language-general, rather than language-specific, perceptual routine. Second, while listeners may have been placed on the “correct” language mode towards the beginning of the labeling task (because they had just heard the instructions in

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