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Phonetics of Early Bilingualism

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Abstract

This article presents an overview of recent research on the phonetics of early bilinguals, individuals who have acquired both of their languages early in life, by either growing up being exposed to two languages since birth (i.e., simultaneous bilinguals) or having initially learned their first language with the second language introduced at a later stage during their childhood (i.e., early sequential or successive/consecutive bilinguals). This review puts forth empirical evidence from methodologically and theoretically diverse studies on the phonetics of early bilingualism and considers explanations for the observed patterns of cross-linguistic influence on the production, perception, and processing of sounds in both of their languages. Throughout, this article discusses the critical significance of early linguistic experience on bilingual speech patterns, how early-onset bilinguals perceive speech sounds in each language, bilinguals' phonetic abilities when producing language-specific segmental and suprasegmental features, and the dynamic nature of cross-language sound interactions in early bilingual speech.

1. INTRODUCTION

Early bilinguals are individuals who have acquired both of their languages early in life, either by being exposed to both languages since birth (i.e., simultaneous bilinguals) or by having initially learned their first language (L1) with the second language (L2) introduced at a later stage during their childhood (i.e., early sequential or successive/consecutive bilinguals). In simultaneous bilingualism, the child acquires two languages at the same time in a process of bilingual first language acquisition (De Houwer 2009, Meisel 2001) and is considered to have two first languages (i.e., 2L1 bilinguals), whereas early sequential (successive or consecutive) bilingualism refers to a process of early L2 acquisition (De Houwer 2009), in which the child has already partially acquired a L1 when learning a L2 early in childhood.

In contrast to early bilinguals, the late bilingual is often described as an individual who acquires the L2 as an adolescent or adult. While there has been general consensus that early bilinguals outperform late bilinguals in their acquisition of various components of the L2 linguistic system, a heated debate ensued for much of the second half of the twentieth century on whether these age effects are due to a sensitive or critical period (DeKeyser 2000, Krashen 1973, Johnson & Newport 1989, Lenneberg 1967, Muñoz & Singleton 2011), or whether there are other factors that correlate or are conflated with previous analyses of age of acquisition (e.g., relative L1/L2 use, amount of input and exposure, L1-L2 similarity, length of residence). In terms of their phonetic abilities, a sizable body of work has consistently shown that, in comparison to late bilinguals, early bilinguals produce and perceive L2 sounds more accurately (Abrahamson & Hyltenstam 2009, Baker & Trofimovich 2005, Guion 2003). Even though the assumption has been that early bilinguals have a benefit in pronunciation as a result of early exposure, interlingual interactions between both of the sound systems of early bilinguals have been widely attested. These bilingual phonetic interactions have been described as a consequence of cross-linguistic influence (CLI), that is, the influence that knowledge of one language has on an individual's learning or use of another language (James 2012). CLI has been a central and well-researched theme in L2 speech learning and early bilingual phonetics and phonology research (for a review, see Amengual 2023).

Early bilinguals undoubtedly form a heterogeneous group with significant differences in their linguistic experience and sociolinguistic profiles, including individuals that reside in societal bilingual settings, speakers of aboriginal or indigenous languages that have been in contact with other standard languages, and heritage speakers of diasporic languages spoken by children or grandchildren of immigrants (Au et al. 2008, Montrul 2023, Mulík et al. 2021). Thus, this early bilingual experience can range from extensive everyday exposure and use of both of their languages to diglossic linguistic contexts in which a minority language is restricted to conversation with family and/or community members while there is a more general use of the majority language outside of the early bilingual's immediate speech community. In order to better understand the phonological and phonetic systems of early bilinguals, it is clear that we need to move beyond age of acquisition effects and consider a wide array of variables, such as language proficiency, language dominance, and language use, together with other extralinguistic variables that may be specific to the experiences of the early bilingual individuals who participate in our research studies.

This article presents an overview of extant findings in the phonetics of early bilingualism and considers explanations for the observed patterns of CLI on the production, perception, and processing of the sound system in both languages. The inclusion of methodologically and theoretically diverse studies is critical to enable discussion on how early bilinguals categorize speech sounds, their sensitivity to phonetic variation, and the phonemic and phonetic abilities of these early-onset bilinguals in their production of language-specific segmental and suprasegmental features. Because of space limitations, this article discusses available evidence from adult early bilinguals of spoken languages without delving into important work on the phonetics of child

bilingualism (see Kehoe et al. 2004) or bimodal bilinguals, who use two languages in different modalities (see Chen Pichler et al. 2009). In Section 2, I first review the research that investigates phonetic CLI as a function of age of acquisition, comparing previous studies on early and late bilingualism. The main reason that the distinction between early and late bilingualism is drawn is that it is more likely that late, rather than early, bilinguals will show influence from their L1 in their L2 at any level of linguistic structure, and this is particularly the case for phonetics and phonology. In Section 3, I reflect on the critical role of early linguistic exposure and its impact on phonetic learning, reviewing studies on international adoptees and childhood overhearers, followed by a comparison of the phonetic behavior between early sequential and simultaneous bilinguals. Section 4 introduces evidence of language dominance effects in bilingual speech production and perception, and Section 5 considers both static and dynamic phonetic interactions to account for observed CLI as a function of language coactivation. To conclude, Section 6 outlines some of the main takeaways on the phonetics of early bilingualism and offers an outlook toward future directions.

2. CROSS-LINGUISTIC PHONETIC INFLUENCE IN EARLY VERSUS LATE BILINGUALISM

As mentioned above, early bilinguals have acquired two languages since birth or during early childhood, and while there is debate concerning the cutoff age, bilinguals are typically classified as early if they are exposed to the L2 before six years of age (Meisel 2009). Researchers have found that brain organization in bilinguals who acquire their L2 before five years of age is different from that of bilinguals who acquire their L2 after that age (Weber-Fox & Neville 1996). On the other hand, the late bilingual is often described as an individual who becomes a bilingual as an adolescent or adult. There is ample evidence that differences in age of acquisition (i.e., late bilingualism versus early bilingualism) are particularly noticeable in the phonetic and phonological domains (Caramazza et al. 1973; Flege 1991, 1999, 2007; Long 1990; Oyama 1976; Patkowski 1990; Scovel 1988; Yeni-Komshian et al. 2000).

Extant research has provided evidence that age of acquisition crucially affects bilinguals' pronunciation development, demonstrating that early bilinguals are less likely to have a foreign or L1-influenced accent than late bilinguals (Baker & Trofimovich 2005; Byers & Yavas 2017; Flege et al. 2003; Piske et al. 2001; Stölten et al. 2014, 2015). For example, Baker & Trofimovich's (2005) study of a subset of English and Korean vowels produced by early and late Korean-English bilinguals revealed that age of acquisition influenced both the degree and the direction of the L1-L2 interaction. In other words, the early Korean-English bilinguals were able to produce distinct acoustic realizations of L1 and L2 vowels to a greater degree than late bilinguals. Similar age effects were revealed by Guion (2003), who showed that early Quichua-Spanish bilinguals produced acoustically distinct Quichua and Spanish vowels, whereas the degree of L1-L2 influence was greater in the acoustic realization of late Quichua-Spanish bilinguals. In addition to research on speech production, studies focusing on how early and late bilinguals categorize speech sounds, their sensitivity to phonetic variation, and the phonemic and phonetic abilities of these bilinguals in their perception of language-specific sounds also indicate that, all things being equal, early bilinguals have an advantage in the perception of L2 segments (Guion 2005, Guion et al. 2004, Stölten et al. 2014). Simply put, in terms of one's phonetic abilities, studies consistently show that earlier is better.

As noted by Piske et al. (2002, p. 50), "the age of exposure to the L2 (i.e., the early versus late distinction) is an important determinant of the extent to which bilinguals can maintain a functional separation, or independence between their two languages." While most studies agree that early learners outperform late learners in various production and perception tasks, the source of age

effects is still controversial. The question that arises is whether early bilinguals maintain separate and independent phonetic systems due to early exposure and extensive experience with both languages, or whether the L1 and L2 sound systems of early and late bilinguals are interrelated and coexist in a common phonetic space, with the bilingual sound system being a combination of the two languages' phonological inventories (Flege 1987, 1995). Evidence of the former comes from studies on bilingual speech production that have observed that early bilinguals produce L1 and L2 sounds free of CLI, suggesting that early exposure helps to develop and maintain independent or separate phonetic systems (Flege & Eefting 1987, Flege et al. 1999, Mack 1989, Sundara & Polka 2008). For instance, a series of studies comparing early English-French bilinguals to monolingual Canadian English and Canadian French speakers producing vowels and stops in each language revealed that early bilinguals were able to form separate phonemic categories across the two languages and were capable of maintaining language-specific contrasts, even for very similar phones (MacLeod & Stoel-Gammon 2005, 2009, 2010; MacLeod et al. 2009). In the latter case, there is the assumption that early bilinguals share a common representational network where there is interaction between the bilingual individual's L1 and L2 (Best & Tyler 2007, Flege 1995, Flege & Bohn 2021, Van Leussen & Escudero 2015). As a result, the bilingual sound system is prone to phonological CLI, independent of age of acquisition.

It is clear that early bilingualism provides the most favorable situation to attain high competence in each language and to overcome interlingual phonetic influence, which most commonly identifies late L2 learners' performance, in the production, perception, and processing of segmental and suprasegmental features in each of their languages. In the following section I consider the critical role of early linguistic exposure and its impact on phonetic learning.

3. EARLY BILINGUALISM: A SENSITIVE PERIOD FOR PHONETIC LEARNING

During their first few years of life, children endure some major developmental milestones with significant cognitive and biological changes while they learn to explore and learn about the things that are around them. This period is also critical for linguistic development. Over the course of the first year of life, infants who are just starting to acquire their speech sound categories have been described as language-general perceivers with universal perceptual abilities, capable of discriminating many segmental speech sound contrasts, including those that are not functional in their mother tongue (Maurer & Werker 2013, Werker & Tees 1992). In other words, monolingual and bilingual infants are considered to be generalized listeners, capable of discriminating between both native and nonnative speech contrasts (Bosch & Sebastián-Gallés 2003, Kuhl & Rivera-Gaxiola 2008, Polka & Werker 1994, Werker and Tees 1984). Note, however, that some authors have described this language generality as an auditory-based perception rather than an ability to perceptually categorize the sounds of any possible language (Aslin & Pisoni 1980, Chládková & Paillereau 2020).

Numerous studies with infants that are usually several months old indicate that the L1 sound system becomes entrenched at a very young age. Language discrimination is an imperative task for the bilingual infant, who very early in life needs to separate the input received by identifying the set of phonetic segments relevant to a specific language and map them onto the phonological categories for that language. These infants develop into specialized or selective listeners. As infants gradually attune to the speech patterns of their native language(s), their language discrimination is closely restricted to the phonemic inventory that occurs in their environment (Bosch & Sebastián-Gallés 2003, Werker & Tees 1984). Therefore, during their first year of life, infants show language-specific perception reflecting their attunement to the phonology of their native language. That is, the L1 sound system appears to filter or warp the perception of L2 sounds (i.e., the perceptual

magnet model) (Kuhl 2000). There is increasing evidence that the input that a bilingual individual receives during the early stages of development is deeply engrained and could shape the perception and production of language-specific categories that may be carried into adulthood. These findings have come from studies on language overhearers or on adult international adoptees who were exposed to a language in childhood, but this early exposure was suddenly discontinued, as well as from research comparing the effect of type of early acquisition on the production and perception of language-specific phonological segments in one of their languages.

3.1. International Adoptees

Support for the critical role of early linguistic experience in phonetic learning has come from studies on international adoptees—adults who had prior exposure to a language during childhood but who had their acquisition process abruptly interrupted or discontinued. In this case, the evidence concerns children who were born in one country but adopted at an early age by a family in another country with a different language. As opposed to early bilinguals who have exposure to both of their languages since birth or very early thereafter, international adoptees only encounter early linguistic experience in their birth language, but because of not having opportunities to use their birth language in the adoptive home environment they acquire the language of their new environment to the detriment of their birth language. This specific context has led to a lively debate in language development research on the role of early linguistic experience and the extent to which international adoptees can access residual knowledge of the birth language, including its sound system.

In the case of international adoptees of Korean origin who were raised by Swedish families, Hyltenstam et al. (2009) found that the later the time of adoption, the better the chances were for access to the L1 remnants when being reexposed to the language. These individuals who had no conscious recollection of their birth language but who had received early input in it demonstrated phonological advantages in the language, which were available during adulthood. Similarly, Choi et al. (2017) showed that Korean adoptees in the Netherlands with no conscious knowledge of Korean significantly outperformed closely matched Dutch speakers with no previous experience with Korean in the speed with which they learned to perceive Korean fortis, lenis, and aspirated stops. The productions of the Korean three-way stop contrast by these Korean adoptees were also more identifiable and highly rated by two groups of native Korean listeners. These results are in line with a previous study on the perceptual abilities of individuals who were born in India and adopted by American families (Singh et al. 2011). The results showed that adoptees performed better than the nonadopted group after perceptual training. These findings support the idea that early experience may be associated with benefits in relearning phonemic contrasts from the language rather than with differences in initial baseline performance.

Neuropsychological data also suggest that early learning of the birth language leaves traces of such knowledge in the adopted language. Results from a French phonological working memory task using functional magnetic resonance imaging (fMRI) reveal that language learning within the first three years of life affects the brain activation patterns of Chinese adoptees when processing sounds in their adopted (and only functional) language (Canadian French), even if the acquisition of their birth language (Chinese) had been discontinued and participants had become monolingual speakers of Canadian French. Their brain activation patterns revealed different neural patterns from those of monolingual French speakers who had never been exposed to Chinese (Pierce et al. 2015), providing neural evidence that very early language experiences have a lasting influence on the way the brain processes the sounds of a language.

In contrast to these findings, it should be noted that at least two other behavioral and brain imaging studies, however, found no evidence for traces of the birth language in international

adoptees, arguing that international adoptees do not necessarily show evidence of an advantage relearning the birth language and that for this specific population the birth language is lost and replaced by the language of their adopted home. In a series of perception and comprehension experiments using fMRI on a group of Korean adults adopted by French families in childhood and who reported no conscious recollection of their birth language, researchers found that these individuals were unable to perceive Korean voiceless stops better than native French speakers with no previous experience with Korean (Ventureyra et al. 2004) and did not outperform matched native French speakers in language identification or word recognition tasks. These behavioral data were also matched by the fMRI data, as the brain activation patterns of the adopted Korean participants were found to be similar to those of the native French group (Pallier et al. 2003).

3.2. Language Overhearers

Evidence of the benefits of early experience on speech learning has also been found in language overhearers, who are individuals who do not know or use a language they were exposed to during early childhood. Several studies have examined the speech production abilities of L2 learners enrolled in language classes who, as children, were exposed to that language without ever acquiring it. In one of these studies, Knightly et al. (2003) showed that adults who were not able to speak Spanish but who were passively exposed to Spanish as children had more native-like Spanish pronunciation than typical late L2 learners. These individuals reported being regularly exposed to Spanish conversations by adult native speakers during their first few years of life even though they were not directly addressed in Spanish or encouraged to speak Spanish as children. This childhood overhearing advantage was shown to be domain specific: It was robust in phonology, a domain that is easy for children to acquire but difficult for adults to master, based on acoustic analyses and accent ratings but was not detectable in morphosyntax (Au et al. 2002). These findings suggest that even incomplete language experience during childhood can have lasting benefits into adulthood (Au et al. 2008).

Oh et al. (2003) examined the perception and production of Korean stop consonants by childhood overhearers of Korean who had heard Korean regularly throughout childhood but did not speak the language, comparing their phonetic abilities to childhood speakers of Korean, novice Korean learners, and native Korean speakers. Interestingly, childhood overhearers outperformed novice learners in the phoneme perception task, but no significant differences between childhood overhearers and novice learners were found in their acoustic realization of Korean stops, and both childhood overhearers and novice Korean learners were outperformed in both perception and production tasks by Korean adults who had spoken Korean exclusively or predominantly prior to starting school at around age five but subsequently stopped using the language.

Casillas & Simonet (2016) examined the production and perception of the English /æ/-/ɑ/ vowel contrast by a group of highly proficient English speakers who were raised by Spanish-speaking families but who became dominant in English during childhood and, as adults, lacked communicative abilities in Spanish and compared them to a group of Spanish-speaking late learners of English who were dominant in Spanish. Both experimental groups differed from native English controls in their production and perception of the English-specific vowel contrast. Their results also indicate that the formative first years of life appear to have a lifelong impact on phonetic behavior, and this seems to hold even in cases where these speakers no longer have productive abilities in the language. Taken together, much of the evidence on childhood overhearers and switched-dominance bilinguals demonstrates long-lasting benefits in speech learning of early exposure to the sounds of a language, even in cases of passive exposure or incomplete acquisition.

3.3. Simultaneous Versus Early Sequential Bilingualism

Corroborating evidence that supports the critical importance of the first years of life for a bilingual individual's phonological development, and more specifically, the quantity and quality of the ambient input received early in life and its available access in adulthood, comes from research that has compared different types of early bilinguals. Recall that early bilinguals may acquire both languages either simultaneously or sequentially. Simultaneous bilingualism occurs when both languages are acquired from birth, or very soon thereafter. Some researchers have preferred to call the languages of a simultaneous bilingual language A and language alpha instead of first and second language (De Houwer 2009). On the other hand, sequential bilinguals are not exposed to the other language until some years later, typically four or five in the case of many heritage speakers (Montrul 2008). Therefore, sequential bilinguals typically go through an early period with exclusive exposure to only one language, whereas simultaneous bilinguals, by being exposed to two languages, have less total exposure in that same language since birth. Based on the critical importance of the first years of life on an individual's phonological development and the differences in the extent and timing of input that simultaneous and early sequential bilinguals receive during this formative period, it is reasonable to hypothesize that the type of early bilingualism could have an impact on the perception and production of language-specific sounds that carry into adulthood.

Some studies have found evidence of the effects of sequential learning on the phonetic behavior of early and highly proficient bilinguals. Sebastián-Gallés et al. (2005), using a lexical decision task, analyzed the perception of a Catalan-specific vowel contrast by two groups of early sequential Catalan-Spanish bilinguals. The Catalan-Spanish bilinguals had been primarily exposed to Catalan since birth and started learning Spanish at the beginning of mandatory schooling at age four. The Spanish-Catalan group had acquired Spanish since birth, and Catalan was learned at the onset of bilingual schooling. The results revealed that the Catalan-Spanish sequential bilinguals performed more accurately in the Catalan lexical decision task than the Spanish-Catalan sequential bilinguals. These findings suggest that the L1 (Catalan) enhanced the ability of the Catalan-Spanish sequential group to perform in Catalan, whereas the L1 (Spanish) of the Spanish-Catalan sequential bilinguals affected their accuracy in the Catalan lexical decision task. When the results for early sequential bilinguals were compared to those of simultaneous bilinguals, the findings revealed that the Catalan-Spanish sequential bilinguals displayed a higher accuracy rate than the simultaneous bilingual group and the Spanish-Catalan sequential group. These results showed that language exposure during the earliest stages of language development affected their lexical representations, influencing their perceptual abilities as adults.

Shifting to speech production, Amengual (2019) compared two groups of Spanish heritage speakers who either were exposed to both languages from birth (i.e., one parent, one language) or had been raised exclusively speaking Spanish at home with Spanish-speaking parents and started learning English in preschool or kindergarten with a group of late English-Spanish bilinguals. This study investigated whether simultaneous and sequential bilinguals differed in their production of allophonic variants (i.e., Spanish spirantization) in their heritage language as a result of differences in the type of early bilingualism. The results showed that sequential bilinguals performed differently than simultaneous bilinguals with respect to the degree of lenition in intervocalic position by producing a more lenited intervocalic bilabial, dental, and velar approximant. These results suggest that for early bilinguals who have been exposed to both the minority (i.e., heritage) language and the majority language early in life, the effects of those structures that were acquired during the formative first years of life are extremely persistent and are carried into adulthood. In a recent production study examining the merger of the voiced palatal lateral /ʎ/ and the voiced palatal fricative /j/ into [j] in Basque and Spanish, Beristain (2021) reported that early sequential (L1 Basque) bilinguals maintain a more robust acoustic distinction between

/ʎ/ and /j/ in Spanish than simultaneous bilinguals (2L1 Basque, Spanish), who show a tendency toward a merger. The findings of both of these production studies on early Spanish-English and Basque-Spanish bilinguals support the claim that differences in the quantity of input and exposure during these early developmental stages have consequences in the production of language-specific segments and match the perception results in Sebastián-Gallés et al. (2005), showing that even the slightest variation in the amount of language exposure during the earliest stages of language development can affect an individual's perceptual abilities into adulthood.

Other studies, however, have found no evidence of differences in the acoustic realization of early sequential and simultaneous bilinguals. For example, the results of a production study comparing simultaneous and early sequential French-English bilinguals in Canada yielded no group differences in their production of labial and coronal stop consonants and high vowels (MacLeod & Stoel-Gammon 2010), and similarly, Welsh-English bilinguals from Welsh-speaking homes and Welsh-English bilinguals from English-speaking homes did not exhibit differences in their acoustic realization of English and Welsh vowels (Mayr et al. 2017). These mixed results suggest that the effects of early and substantial exposure to a language may appear long-lasting and persistent in some cases, but this outcome is also compatible with the possibility that the effects of linguistic experience can be overridden under certain social conditions, such as peer group identity and status of each language in the bilingual communities (Morris 2014).

There is substantial evidence indicating that the first years of life are an extremely sensitive period for phonetic learning; that, in many cases, the input that a bilingual individual receives during the earliest and formative stages of development is deeply engrained and may shape their perception and production abilities; and that these patterns may be detectable in adulthood. Prior research also consistently shows that early acquisition alone does not reduce the evidence of CLI in early bilinguals' phonetic behavior (Bosch et al. 2000, Pallier et al. 1997, Sebastián-Gallés & Bosch 2002, Sebastián-Gallés & Soto-Faraco 1999). Even though early bilinguals who continue to use their two languages on a daily basis have been considered to be more proficient than those who acquired their L2 later in life, bilinguals have a preferred or dominant language. There is ample evidence demonstrating that early bilinguals can encounter difficulties producing and perceiving certain sounds in their nondominant language despite the fact that they acquired both of their languages in early childhood, have many years of experience and everyday use of both languages, and have attained a high proficiency in their nondominant language. The following section delves into language dominance effects in the production and perception of early bilinguals.

4. LANGUAGE DOMINANCE EFFECTS IN THE PHONETICS OF EARLY BILINGUALISM

Even though early bilinguals frequently demonstrate a high level of competence in both languages, they usually have a dominant, or stronger, language (Cutler et al. 1989, 1992; Flege et al. 2002). Language dominance refers to "the observed asymmetries of skill in, or use of, one language over the other" (Birdsong 2014, p. 374) and covers many dimensions of language use and experience, such as proficiency, fluency, ease of processing, frequency of use, or cultural identification. Language dominance in bilinguals is dynamic, and the dominant language of a bilingual individual can change across the life span.

Among the variables that have been included to examine the phonetic abilities of early bilinguals, language dominance has consistently been shown to be an important predictor of the speech production and perception patterns of early bilinguals across a wide range of bilingual settings, including language contact scenarios of typologically similar (e.g., Spanish-Catalan, Spanish-Galician) and dissimilar (e.g., Spanish-Hñäñho, Spanish-K'ichee', Afrikaans-Spanish) languages in minority language contexts and societal bilingual settings (Amengual 2016a,b,c,d, 2018; Amengual

& Chamorro 2015; Antoniou et al. 2010, 2011, 2012; Baird 2021; Bullock et al. 2006; Casillas 2015; Casillas & Simonet 2016; Henriksen et al. 2021; Kim & Repiso-Puigdelliura 2020; Mayr et al. 2019; Mulík et al. 2023; Ramírez & Simonet 2018; Simonet 2010, 2011, 2014). It is important to note, however, that language dominance in early bilingualism has not been measured identically across studies. As a result, a variety of instruments and criteria have been used to classify bilingual participants as a function of their dominance, including questionnaires (Birdsong et al. 2012, Dunn & Fox Tree 2009, Lim et al. 2008, Marian et al. 2007), self-ratings on language background and exposure, language use, and other social variables (Tomé Lourido & Evans 2019); self-ratings of their fluency in each language and daily language use (Antoniou et al. 2012); and self-assessments of speaking, understanding, writing, and reading in each language and sentence duration ratios for repetition of orally presented sentences in each language (Flege et al. 2002).

4.1. Language Dominance and Early Bilingual Speech Production

A demonstration of the predictive potential of language dominance in the phonetic production patterns of early bilinguals is Simonet's (2011) study of Catalan and Spanish back mid-vowel production among highly proficient, early-onset Catalan-Spanish bilinguals, divided as a function of their language dominance. Crucially, Catalan distinguishes /e/ and /ɛ/, and /o/ and /ɔ/, while Spanish only has /e/ and /o/ as mid-vowel phonemic categories. The acoustic analyses indicated that the Spanish-dominant bilinguals did not produce two distinct Catalan-specific phonemic categories but instead produced a single, merged phonetic category, whereas Catalan-dominant bilinguals produced two mid-back vowel categories, one for Catalan /ɔ/ and another one for a merged Catalan /o/ and Spanish /o/. In a follow-up study that examined the perception and production of the front and back Catalan mid-vowel contrasts /e/–/ɛ/ and /o/–/ɔ/ in the same bilingual community, Amengual (2016b) showed that even though these bilinguals maintained robust mid-vowel contrasts in their productions, the degree of language dominance had an impact on the acoustic (Euclidean) distance maintained between their mid-vowel targets.

In an investigation of the acoustic correlates of the Spanish tap-trill phonological contrast in the acoustic realization of Spanish heritage speakers and L2 Spanish learners, Amengual (2016d) showed that most of the L2 learners and English-dominant heritage speakers produced noncanonical phonemic trills with one or zero occlusions and maintained the Spanish tap-trill contrast largely by means of segmental duration. In contrast, Spanish-dominant heritage speakers produced most of their trills with two or three occlusions. These findings suggest that English-dominant early bilinguals are most likely to exhibit a modified system to maintain the intervocalic rhotic phonological contrast, ultimately showing that even though these heritage speakers, an undoubtedly heterogenous early bilingual group, maintain the rhotic contrast in Spanish, their production patterns differ as a function of their language dominance.

At the suprasegmental level, Baird (2015) presented an acoustic analysis of peak alignment in prenuclear tonic syllables of broad-focus declaratives produced by Spanish-K'ichee' bilinguals in Guatemala. The Spanish fundamental frequency (F0) peak typically occurs after the tonic syllable, whereas its placement is variable and often pretonic in contact and bilingualism contexts. On a task involving reading aloud a set of Spanish declarative phrases, the peak F0 placement on paroxytone target words was analyzed in the speech of Spanish-dominant and K'ichee'-dominant bilinguals together with those of Guatemalan Spanish monolinguals. The results revealed a significant correlation between language dominance and average relative peak alignment. Specifically, the direction and degree of dominance at the level of the individual bilingual participant predicted both the observed direction and distance of peak F0 placement relative to the Spanish tonic syllable.

Although this evidence of the effects of language dominance on early bilingual speech production appears to be robust, it may not be sensitive enough to uncover the sources of variation in certain phonological processes. Amengual & Simonet (2020) compared the effects of language dominance on the acoustic realization of the Catalan [a]~[ə] alternation (a phonological process induced by lexical stress) and the Catalan mid-vowel contrasts /e/-/ɛ/ and /o/-/ɔ/ (two phonemic contrasts). The results of two production experiments revealed that even though the first one showed significant differences between Spanish-dominant and Catalan-dominant bilinguals in their production of the Catalan mid-vowels, these effects were not found with respect to vowel reduction. The authors postulated that unstressed vowel reduction ([a]~[ə]) may be relatively easier to acquire than phonemic contrasts with a low functional load (/e/-/ɛ/, /o/-/ɔ/), perhaps because its predictability and high frequency attract attention and/or relieve cognitive resources, which could be conducive to phonetic learning. These findings point to the need to further investigate the predictive potential of language dominance in the acquisition of phonemic contrasts as well as phonological processes in early bilingualism. In other words, language dominance may impact patterns of CLI in the sound systems of bilinguals to a different degree, depending on the phonological variables under investigation (e.g., language-specific phonological contrasts, allophonic distributions, primary or secondary acoustic cues).

4.2. Language Dominance and Early Bilingual Speech Perception

Early bilinguals do not only display traces of their dominant language in the acoustic realization of their nondominant language, that is, speaking with an accent, but they also hear with an accent (Jenkins et al. 1995). Even though available evidence on early bilingual speech perception is based on fewer studies in comparison to those on early bilingual speech production, recent studies have explored the effects of language dominance in the perception and processing of early bilingualism. For instance, a series of perceptual studies have examined the patterns of interaction between early Spanish-Catalan bilinguals' dominant and nondominant languages. This research investigated the perceptual abilities of Catalan-dominant and Spanish-dominant bilinguals in Majorca (Spain) toward Catalan mid-vowels (/e/-/ɛ/, /o/-/ɔ/), phonemic contrasts that have been reported to be particularly difficult for Spanish-dominant bilinguals to perceive and produce (Cortés et al. 2009, Mora & Nadeu 2012, Pallier et al. 1997, Sebastián-Gallés et al. 2005, Sebastián-Gallés & Soto-Faraco 1999).

In a study of 30 Spanish-dominant and 30 Catalan-dominant early Spanish-Catalan bilinguals, Amengual (2016b) explored the perceptual robustness of the Catalan mid-vowel contrast in comparison to other vowel contrasts in Catalan by means of a categorical AXB discrimination task and a picture-naming task. The results of the perception experiment showed that the Catalan mid-vowels, which share the same acoustic-perceptual space as the Spanish mid-vowels, were particularly difficult for Spanish-dominant bilinguals to perceive. The perception and processing of these Catalan-specific mid-vowel contrasts were further explored at the levels of segmental categorization and lexical representation by Amengual (2016c), who showed that even though Spanish-dominant and Catalan-dominant bilinguals were both able to accurately perceive the contrast between the Catalan-specific /e/-/ɛ/ and /o/-/ɔ/ phonemic categories in perceptual identification and AX discrimination tasks, their performance dramatically decreased in a lexical decision task in which they were required to identify experimental words and nonwords that differed in the Catalan mid-vowel contrasts. Furthermore, Spanish dominants exhibited higher error rates than Catalan dominants. Lastly, Amengual (2016a) examined the phonetic production and processing of the Catalan mid-back vowel contrast (/o/-/ɔ/) in a comparable group of Catalan-dominant and Spanish-dominant early Spanish-Catalan bilinguals. In the analysis of their perceptual abilities in

a lexical decision task, the early bilinguals who were more Spanish dominant displayed a higher error rate and a slower reaction time when responding to cognate and noncognate lexical items. These language dominance effects in speech perception corroborate the results of Ramírez & Simonet (2018), who explored the discrimination of /ʎ/–/ʒ/ in Majorcan Catalan, a contrast that does not have a direct equivalent in Spanish, in two groups of Catalan-Spanish bilinguals. In their analysis of an odd-item-out AXB discrimination task, Spanish-dominant bilinguals were found to be less sensitive to the /ʎ/–/ʒ/ contrast than Catalan dominants.

Mid-vowel perceptual data from early Spanish-Galician and English-Portuguese bilinguals also show a similar picture. In a study exploring the production and perception abilities of early Spanish-Galician bilinguals (Amengual & Chamorro 2015), Spanish dominants exhibited great difficulties in discriminating between the Galician mid-vowel contrasts /e/–/ɛ/ and /o/–/ɔ/ in forced-choice identification and AX discrimination tasks. In contrast to Galician-dominant bilinguals, who demonstrated a clear categorization between two distinct mid-vowel phonemes, the Spanish-dominant bilinguals did not accurately identify the stimuli along the /e/–/ɛ/ and /o/–/ɔ/ continuum. By means of an AXB discrimination and a two-alternative forced-choice identification task, Osborne (2021) similarly investigated the perception of Brazilian Portuguese mid-vowel contrasts by early Portuguese-English bilinguals residing in the United States. Her findings revealed that the group of early bilinguals who were more dominant in English had more difficulties categorizing the /o/–/ɔ/ contrast than those in the group with less dominance in English.

In this section, we have seen that language dominance, understood as a "by-product of linguistic experience, determined by factors, such as age of acquisition, self-reported frequencies of language use, self-rated proficiency, and even linguistic ideologies" (Amengual & Simonet 2020, p. 849), is a strong predictor of the phonetic behavior of early bilinguals. However, this variable may also interact with other factors, such as the relative degree of activation of each language as a function of the communicative setting (e.g., bilingual versus monolingual discourse). In these different language contexts, we can expect a deviation of the phonetic implementation toward the nontarget language, and these effects are likely either mitigated or exacerbated as a function of language dominance. In the following section, I expand on the phonetics of early bilingualism research focusing on code-switching, language mode, and cognate status.

5. STATIC PHONETIC INTERACTIONS VERSUS DYNAMIC INTERFERENCE IN EARLY BILINGUALISM

As mentioned above, the degree of CLI in the phonetic and phonological abilities of early bilinguals is closely associated with age of exposure, language dominance, quantity and quality of the input, relative L1/L2 use, and even typological proximity/distance. But it is important to note that bilingual individuals speak or hear both of their languages in a variety of linguistic contexts depending on the interlocutor, the communicative purpose, or the linguistic intent. Early bilinguals are among those who can use their two languages in single-language contexts or in dual-language contexts that require joint activation, for instance, when code-switching (Green 2011, Green & Wei 2014, Olson 2016, Van Hell 2023).

The CLI between the two sound systems of early bilinguals can be the result of either static or dynamic phonetic interactions as a function of the communicative context. Static phonetic interactions are the result of long-term traces of one language influencing the other, and this process is the consequence of cross-linguistic interactions between long-term memory representations. Alternatively, a short-term (dynamic) phonetic interaction can occur when the communicative context requires bilinguals to coactivate both of their linguistic (and sound) systems during dual-language discourse processing. This dynamic process involves interactions between representations that

are coactivated in working memory. There is a general consensus that both languages are, to various degrees, simultaneously active in the mind of early bilinguals (Kroll et al. 2014), and transient phonetic interactions can arise even in relatively short-term changes in the linguistic environment (Sancier & Fowler 1997). When both languages are activated because the early bilingual individual is required to use both languages, this creates competition between the phonetic representations of the target and nontarget language during online speech processing and can cause interference in bilingual speech (Grosjean 2001).

Relative to the extensive body of research on static (long-term) phonetic interactions, dynamic (short-term) interference is less well represented in the early literature on this topic. Within research on short-term phonetic interference, three areas of inquiry have been the most productive to date: code-switching, language mode, and cognate status. This work has provided a cascade of evidence that there is a cost in bilingual language processing: Dual activation can have immediate effects on the phonetics of both languages of the early bilingual individual.

5.1. Code-Switching

Code-switching has been defined as "the use of two or more languages in the same conversation, usually within the same conversational turn, or even within the same sentence of that turn" (Myers-Scotton 1993, p. 47). Even though not all bilingual individuals engage in code-switching, this kind of systematic and rule-governed alternation between two or more languages generally happens among highly competent bilinguals for a variety of social and pragmatic functions (Bullock & Toribio 2009a). A growing body of research has shown that code-switching can result in phonetic interference between both languages of the bilingual individual (Balukas & Koops 2015, Bullock & Toribio 2009b, Bullock et al. 2006, González López 2012, Olson 2013, Piccinini & Arvaniti 2015, Tsui et al. 2019).

To provide a few examples, Antoniou et al. (2011) observed that early Greek-English bilinguals produced distinct categories for English and Greek stops, but the code-switching context revealed values in the nondominant language that converged toward the range of their dominant language. Similarly, Henriksen et al. (2021) reported that even though early Afrikaans-Spanish bilinguals in Patagonia (Argentina) produced distinct intervocalic voiced stops in each language, code-switched Spanish targets were found to display less lenition of intervocalic [β,ð,ɣ] (i.e., more influence from Afrikaans), whereas code-switched Afrikaans targets resisted influence from Spanish. These results are in line with a series of studies analyzing the acoustics of early Spanish-English bilinguals' code-switching patterns, which showed that the production in both languages can be mutually impacted by code-switching, that an asymmetrical pattern of CLI can be detected in only one of the languages in the acoustic realization of phonological processes (i.e., voicing assimilation, spirantization), and that these language-switching costs are also observed in auditory comprehension (Olson 2016, 2017, 2019).

5.2. Language Mode

Language mode has been defined as the state of activation of the bilingual's languages and language processing mechanisms at a given point in time (Grosjean 1998, 2001). The language mode framework (Grosjean 2001) postulates that just one of the bilingual's languages (monolingual mode) or both languages (bilingual mode) will be activated as a consequence of the communicative context. A monolingual mode occurs when the interlocutor or the communicative context requires that only one language be used to the exclusion of the other, whereas a bilingual mode arises if the interaction occurs between two bilingual individuals who share the same language and who feel comfortable mixing languages or when a bilingual is listening to a conversation that contains elements of the other language.

Extant evidence reveals that experimental designs that manipulate language mode are able to capture fine-grained differences in the acoustic realization of language-specific phonetic categories as well as language-specific perceptual routines (Amengual 2018, Antoniou et al. 2011, Casillas & Simonet 2018, Simonet 2014, Simonet & Amengual 2020). For instance, Amengual (2018) examined the effects of language mode on the acoustic realization of Spanish and English laterals by early and late Spanish-English bilinguals who read target words embedded in carrier sentences in a monolingual English session, a monolingual Spanish session, and a bilingual English/Spanish session. The acoustic analyses showed that when in bilingual mode, all four groups of bilinguals produced a less target-like lateral in their nondominant language in comparison to their productions in the unilingual session. In a similar experimental design, Simonet & Amengual (2020) analyzed early Spanish-Catalan bilinguals' acoustic realization of Spanish and Catalan unstressed /a/, which surfaces as [a] in Spanish but is reduced to schwa, [ə], in Catalan. The results revealed that Catalan unstressed /a/, which was similarly reduced to schwa in the speech of all participants, became slightly more similar to Spanish unstressed /a/ [i.e., it had a higher first-formant (F1) frequency] when produced alongside Spanish words (bilingual setting) than when produced in a Catalan unilingual setting. These results match those reported in a study examining language mode effects in the production and perception of the Catalan mid-back vowel contrast /o/–/ɔ/ in a comparable group of highly proficient, early-onset Catalan-Spanish bilinguals (Simonet 2014). The results of the production task revealed that both Catalan vowels /o/ and /ɔ/ were affected by the coactivation of Spanish, in that they were produced with lower F1 frequencies in the bilingual session in comparison to the unilingual session. Taken together, these findings point to language mode effects, elicited experimentally, in the speech patterns of early bilinguals.

5.3. Cognate Status

Cognates are translation equivalents with a considerable degree of orthographic, phonological, and semantic similarity or overlap between languages due to their common etymological origin or borrowing (e.g., *terrible* in English, French, Spanish, Galician, and Catalan). A sizable number of speech production and recognition studies have consistently shown that bilinguals are faster and more accurate at processing cognates in comparison to noncognates (Carrasco-Ortiz et al. 2021; Christoffels et al. 2006, 2007; Costa et al. 2000; de Groot et al. 2002; Schwartz et al. 2007). As cognates "represent the lexical overlap between languages" (Lemhöfer et al. 2004, p. 587), it is reasonable to hypothesize that, in addition to facilitation effects and processing advantages, there may also be a cognate effect in the phonetic abilities of bilingual individuals.

A growing body of empirical studies have taken a within-subjects design, comparing a single bilingual speaker's acoustic realization of segments across different stimuli types based on cognate status. This research has shown that the activation of nontarget phonological representations when bilinguals pronounce cognate items interferes with the acoustic realization of sounds in the target language, enhancing CLI. In other words, cognate words seem to be subject to a higher degree of interference from the nontarget language than noncognates for early and late bilingual as well as trilingual speakers (Amengual 2012, 2016a, 2021; Brown & Amengual 2015; Flege & Munro 1994; Fricke et al. 2016; Goldrick et al. 2014; Jacobs et al. 2016). As postulated by Goldrick et al. (2014, p. 1036), "the activation of nontarget language representations for cognates will cascade to phonetic processes, enhancing the degree to which phonetic properties of the nontarget language intrude during production."

The empirical work reviewed in this section demonstrates that early bilingual speech production and perception are impacted by the increased activation of the nontarget language required in certain communicative contexts and experimental procedures. In addition to exploring long-term

(static) traces of the dominant language when using the nondominant language, future research on early bilingual phonetics should also consider short-term (dynamic) interference from the nontarget language to more thoroughly describe the phonetics of early bilingualism in dual-language settings. Arguably, these dynamic (short-term) phonetic interactions most accurately reflect the typical communicative scenarios that involve early bilingual individuals.

6. CONCLUSION

Due to having acquired both of their languages early in life and because they very frequently demonstrate a high level of proficiency in each language, it has been assumed that early bilinguals have an advantage in phonetic learning. Early bilinguals, however, are an inherently heterogeneous group in terms of the amount and extent of their relative L1-L2 language use, language dominance, accessibility to formal education in one or both of their languages, speech community size, and attitudes toward each language. Scholars in this interdisciplinary area of inquiry have contributed empirical data from an increasing number of language pairs, novel data collection techniques and experimental designs, and sophisticated acoustic analyses that have led to results with robust theoretical implications. These studies are forging bridges between theoretical linguistics, language acquisition, psycholinguistics, sociolinguistics, and applied linguistics. In addition to replication studies that can resolve the mixed results obtained in previous research on international adoptees and simultaneous and early sequential bilinguals, future research on the phonetics of early bilingualism will benefit from longitudinal approaches that are able to capture the dynamic nature of language dominance and its effects on the phonetic abilities of bilingual individuals throughout their life span. Studies that incorporate typological proximity and distance in their examination of a wider range of language pairs in early bilingualism will be similarly important. Additionally, as recent work has suggested that bilinguals may have an advantage over monolinguals in subsequent phonetic learning (Antoniou et al. 2015, Tremblay & Sabourin 2012), a significant contribution will be to include fine-grained analyses of the phonetic behavior of simultaneous and early sequential bilinguals and compare them to late L2 learners to shed light on the possibility of this early bilingual advantage when acquiring a third language.

In closing, by integrating a wide range of experimental approaches, including the analysis of acoustic properties of speech sounds, perceptual and neurocognitive procedures, sociolinguistic methods, and computational modelling, the phonetics of early bilingualism provides an exceptional opportunity to answer fundamental questions about language acquisition and the properties and principles of phonetic science: How do language experience, language learning history, language dominance, proficiency levels, and social and cognitive factors affect the production, perception, and processing of both languages of the bilingual individual? How can we explain the variability in speech production and perception of early bilinguals, and how can we better understand observable patterns of phonetic CLI? The steady increase in research on the phonetics of early bilingualism promises to enrich our understanding of how the sound systems of early bilingual individuals interact and, consequently, the impact on their speech production and perception abilities. We can look forward to many new discoveries in the years to come, with findings that will inform speech learning models as well as theories of language development and language acquisition.

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