Title: The role of early experience and continued language use in bilingual speech production: A study of Galician and Spanish mid vowels by Galician-Spanish bilinguals

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Abstract
This paper examines the vowel productions of three groups of adult Galician-Spanish bilinguals: Spanish-dominant (SD) bilinguals, Galician-dominant (GD) bilinguals, and Dual Switch (DS) bilinguals who had early experience with Galician in the home, predominantly used Spanish upon school entry, but in adolescence/ adulthood switched to Galician for ideological reasons.
To examine how linguistic experience with Galician and Spanish affected the participants' speech, a cued picture-naming task, conducted in unilingual and codeswitched conditions, was used to elicit the Galician mid vowel contrasts /e-ɛ/ and /o-ɔ/ and the Spanish mid vowels /e/ and /o/.
The results revealed no difference in either condition in normalised F1 and F2 across the front and back vowels in the two languages. These patterns not only held for the SD bilinguals, for whom vowel mergers were expected, but also the DS and GD bilinguals. As such, the study is the first to document widespread mergers of Galician mid-vowels in bilinguals with extensive early Galician language experience and regular use, and to demonstrate overlap with Spanish mid-vowel categories. The findings suggest that psycholinguistic factors, such as age of acquisition or language use, can only partially explain the data and that input-related and socio-indexical factors are equally critical in understanding the acquisition and maintenance of language-specific speech patterns.

Keywords
Vowel productions; acoustic analysis; Galician-Spanish bilingualism; language dominance; code-switching; language mode

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1.0 Introduction

The speech patterns of our native language are never entirely static but undergo change throughout our lifespan (Harrington, 2006; Harrington, Palethorpe & Watson, 2000; Norris, McQueen & Cutler, 2003; Reinisch, Vosni, Mitterer & Holt, 2014). This is particularly pertinent in bilinguals for whom change may arise from the interaction of different sound systems and variations in input and language use (Flege, 1995; Flege, Schirru & MacKay, 2003; Piske, MacKay & Flege, 2001). As such, bilingual speech development is highly dynamic and multi-faceted. Changes in first language (L1) and second language (L2) speech may have long-term effects on memory representation, or manifest as fast and transitory (Chang, 2012, 2013; Sancier & Fowler, 1997). There is evidence that early linguistic experience may be particularly deeply entrenched and can have long-lasting effects (Amengual, 2017; Au, Oh, Knightly, Jun & Romo, 2008; Choi, Cutler & Broersma, 2017; Hyltenstam, Bylund, Abrahammson & Park, 2009); at the same time, it is not immune to change, and may even be overridden in individuals who only became bilingual in adolescence or adulthood (Ahn, Chang, De Keyser & Lee-Ellis, 2017; Bergmann, Nota, Sprenger & Schmid, 2016; de Leeuw, Schmid & Mennen, 2010; de Leeuw, Tusha & Schmid, 2017; de Leeuw, Mennen & Scobbie, 2013; Dmitrieva, Jongman & Sereno, 2010; Mayr, Price, Mennen, 2012; Mennen, 2004).

Nevertheless, it is still not fully understood under what conditions language-specific patterns are acquired in bilingual settings, and what role early linguistic experience and continued use play in this context. Moreover, it is not clear how these language-specific features are realised in the other language or in contexts of language switching. The present study aimed to address these questions on the basis of Galician and Spanish mid-vowel productions by three groups of Galician-Spanish bilinguals who differ in their linguistic experience.

1.1 Interactions and change in bilingual speech

Bilinguals have separate, but non-autonomous sound systems that constantly interact with each other (Flege et al., 2003; Paradis, 2001). Such interactions have been widely documented across the lifespan, and can occur in a range of settings, including migration, heritage language contexts and societal bilingualism (e.g., Flege, Munro & MacKay, 1995; Guion, 2003; Kupisch, Barton, Hailer, Klaschik, Stangen, Lein & Weijer, 2014; Mayr & Siddika, 2018). They may only affect the L1, or the L2, or both. According to the *Speech Learning Model* (SLM) (Flege, 1995; Flege et al., 2003), interactions arise from interlingual identification of L1 and L2 categories. Thus, where cross-linguistically similar sounds are perceptually equated, they form merged L1-L2 representations, a phenomenon termed *equivalence classification*. A particularly well-known example is the difficulty that Japanese learners of English experience with the /r/ - /l/ contrast, which they map onto their single L1 liquid category (Aoyama, Flege, Guion, Akahane-Yamada & Yamada, 2004). Alternatively, where bilinguals are able to perceive a cross-linguistic contrast, they may strive to maximise the differences between the L1 and L2 sounds. For example, Italian learners of English produced English /eɪ/ with exaggerated vowel-inherent spectral change in order to enhance its distinction from monophthongal Italian /e/ (Flege et al., 2003). Both mechanisms can lead to patterns that differ from those of monolingual speakers. Other models on bilingual speech learning offer similar explanations. The *Perceptual Assimilation Model* (PAM, Best, 1995; PAM-L2: Best & Tyler, 2007), for instance, predicts difficulties in the perception of non-native contrasts on the basis of how they map onto native categories.

While interactions are widely assumed to affect long-term memory representations, in particular in the presence of stable linguistic environments, they can also manifest as quick and transitory phenomena. Thus, Sancier & Fowler (1997) documented quick changes in the voice onset time (VOT) patterns of a late Portuguese-English bilingual who regularly travelled between Brazil

and the United States. Specifically, her VOTs were longer in both languages after several months in the United States, and shorter in both languages after months in Brazil. Similarly, Chang (2012, 2013) reported rapid changes in L1 stops and vowels by novice learners of Korean following a six-week intensive language course in Korea. Interestingly, experienced learners of Korean did not show the same extent of phonetic drift, which led Chang (2013) to stipulate a novelty effect for inexperienced learners.

Interactions may also occur in situations that require dual language activation, such as during code-switching, where inhibition of the non-target language may be particularly challenging (Green, 1998). The state of activation of a bilingual's two languages is referred to as *language mode* (Grosjean, 2001) and can vary on a continuum from monolingual mode, where the non-target language is maximally inhibited, albeit never completely, to bilingual mode, where both languages are fully activated, based on sociolinguistic factors. Studies of phonetic code-switching have taken a number of methodological approaches, including naturalistic and experimental designs, and revealed both asymmetrical unilingual interactions (Antoniou, Best, Tyler & Kroos, 2011; Muldner, Hoiting, Sanger, Blumenfeld & Toivonen, 2017; Olson, 2013) and bidirectional interactions (Bullock & Toribio, 2009; Piccinini & Arvaniti, 2015), although some found no effect of switching (Grosjean & Miller, 1994). Moreover, there is evidence that phonetic switching is more prevalent for cognates than non-cognates (Jacobs, Fricke & Kroll, 2016). Of particular interest for the present study, Simonet (2014) found that Catalan /o/ and /ɔ/ were produced with lower F1-f0 values in switched contexts, in which Catalan and Spanish items were alternated, than unilingual contexts, and hence with more Spanish-like properties. In the following section, we will review the factors that make interactions more likely, in particular the role of early linguistic experience.

1.2 Early linguistic experience, language use and dominance

It has been widely demonstrated that age critically affects accent acquisition in bilinguals (Flege, Munro & MacKay, 1995; Flege, Schirru & MacKay, 2003: Yeni-Komshian, Flege & Liu, 2000). Thus, individuals who acquire a second language (L2) late, i.e. in adolescence or adulthood, virtually always exhibit some degree of foreign accent in it (see Colantoni, Steele & Escudero, 2015 for an overview), while this is much less likely in individuals with early exposure to a language in childhood (Guion, 2003; Kupisch et al. 2014; MacLeod, Stoel-Gammon & Wassink, 2009). For example, the early French-English bilinguals from Canada in MacLeod et al.'s (2009) study (age of L2 learning <4 years) did not differ in their vowel productions from monolingual speakers of either language. Similarly, in Guion's (2003) study of four types of L1 Quichua-L2 Spanish bilinguals, simultaneous, early and some mid bilinguals managed to produce their vowels distinctly in the two languages, while late bilinguals produced vowels in both languages with L1 Quichua-like properties, and hence had not acquired Spanish vowel categories.

Some have explained such age-related differences on the basis of maturational changes in cerebral plasticity, postulating a critical or sensitive period for acquisition (Lenneberg, 1967; Long, 1990; Scovel, 1988). However, the correlation between age of onset of learning and degree of foreign accent is steady, without any sharp discontinuities (Flege, 1995; Flege et al., 1995). Moreover, there is evidence that a native-like accent in an L2, while rare, is not impossible to attain in adulthood (Birdsong, 2007; Bongaerts, Mennen & Slik, 2000), and that speech is malleable throughout life (Harrington, 2006; Norris et al., 2003; Reinisch et al., 2014). As a result, many have rejected maturation-based accounts, and instead explain age-related differences on the basis of other factors, such as L1 and L2 use (Flege, Frieda & Nozawa, 1997; Yeni-Komshian et al., 2000).

Irrespective of one's theoretical stance, there is a general consensus that children's early experience with speech is hugely influential for their subsequent development. During the first year of life, monolingual and bilingual children are initially language-general perceivers, capable of discriminating both native and non-native contrasts, but subsequently become highly

selective listeners and attune to the speech patterns of their native language or languages (Bosch & Sebastián-Gallés, 2003; Fennell, Sin-Mei Tsui & Hudon, 2016; Narayan, Werker, & Beddor, 2010; Werker & Tees, 1984). Experiences made during that period remain deeply engrained, and may be carried into adulthood. Thus, international adoptees who forgot their birth language following adoption in an L2-speaking environment have been shown to retain some residual knowledge of their L1 speech patterns (Hyltenstam, Bylund, Abrahammson & Park, 2009; Pierce, Chen, Delcenserie, Genesee & Klein, 2015) although other studies did not find this effect (Pallier, Dehaene, Poline, LeBihan, Argenti, Dupoux & Mehler, 2003; Ventureyra, Pallier & Yoo, 2004). Moreover, they may be able to access it during re-exposure to the birth language in adulthood, thereby outperforming otherwise matched individuals who do not possess this knowledge (Choi, Cutler & Broersma, 2017).

Nevertheless, early linguistic experience does not always result in speech patterns that are akin to those of monolingual speakers. Thus, while heritage language speakers are generally closer in accent to monolinguals in the heritage language than L2 learners (Au, Knightly, Jun & Oh, 2002; Amengual, 2017; Chang, Yao, Haynes & Rhodes, 2011), there are usually differences in their speech patterns (Kupisch et al., 2014; McCarthy, Evans & Mahon, 2013; Oh, Jun, Knightly & Au, 2003). For example, Kupisch et al. (2014) showed that heritage language speakers from Germany, France and Italy with exposure to both languages from birth were perceived as foreign-accented from a monolingual native speaker perspective.

One factor that may explain these patterns is the amount of cumulative early experience that these children received in the heritage language. Thus, Amengual (2017) showed that Spanish heritage language speakers in the United States who only heard Spanish in the home as children, i.e. consecutive bilinguals, produced more native-like spirantisation patterns in Spanish as adults than otherwise matched Spanish heritage language speakers who had heard Spanish alongside English in the home, even though both sets of bilinguals had been exposed to the heritage language from birth.

In addition, native-like speech may require regular language use, in particular where input is limited to a small number of speakers (Mayr & Montanari, 2015). In bilingual settings, usage patterns are dynamic, and will wax and wane depending on social circumstances (Simon, 2010). A particularly critical event in many bilingual settings, specifically where education in the minority language is restricted, is the onset of mainstream education, which commonly coincides with a switch in language dominance from the home language to the majority language (de Houwer, 2009). While this is often beneficial for the latter (McCarthy, Mahon, Rosen & Evans, 2014), it may adversely affect pronunciation proficiency in the minority language. Thus, Oh et al. (2003) found that adults who used Korean exclusively or predominantly up to school entry at age 5, but subsequently stopped using the language altogether, were significantly less accurate in the production of Korean plosives and obtained significantly lower accent ratings than native Korean speakers, although they outperformed novice learners of Korean. Similarly, Mora & Nadeu (2012) showed that Catalan-Spanish bilinguals who were raised in Catalan-only homes and first had significant exposure to Spanish when entering school at age 4-5 produced Catalan /ɛ/ with Spanish-influenced features if their daily use of Spanish was high, but not if it was low. Finally, Cortés, Lleó and Benet (2018) examined the production of Catalan /e-ɛ/ in children and adults from predominantly Catalan-speaking and predominantly Spanish-speaking districts of Barcelona. They found that the predominant language of the environment, rather than home language use, was the strongest predictor for acquisition of the Catalan-specific vowel contrast, and hence even children from Catalan-speaking homes who lived in a predominantly Spanish-speaking neighbourhood did not differentiate /e-ɛ/. Taken together, these results suggests that in addition to early linguistic experience, continuous exposure to language-specific patterns may be required in order to maintain them.

1.3 Mid vowel contrasts and the Galician context

This study investigated mid-vowel productions in three groups of Galician-Spanish bilinguals from Vigo, Galicia. Mid vowels were selected as they differ cross-linguistically, with Galician containing a front and a back vowel contrast in stressed syllables, i.e. /e-ɛ/ and /o-ɔ/ (Regueira, 1996), while Spanish only distinguishes a single mid front and mid back vowel. Previous work from Galician and other Romance languages, has shown that these contrasts are particularly difficult to acquire and maintain (Amengual, 2016; Amengual & Chamorro, 2015; Mora, Keidel & Flege, 2015; Mora & Nadeu, 2012; Nadeu & Renwick, 2016; Pallier, Bosch & Sebastián-Gallés, 1997; Renwick & Ladd, 2016; Renwick & Nadeu, 2018; Tomé Lourido & Evans, 2015, 2018; Simonet, 2011). This instability has not only been documented in bilingual settings where acquisition and maintenance may be adversely affected by interaction with a language that lacks mid vowel contrasts, as in the case of Galician and Catalan, but also in monolingual settings. Renwick & Ladd (2016), for instance, found that although monolingual Italian speakers mostly produced phonetically distinct mid-vowel categories, they varied in their judgements of vowel height, and the mapping of mid-vowel categories to lexical items was inconsistent.

Difficulties with mid vowels have been explained on the basis of typological considerations and perceptual biases. Thus, mid vowel contrasts are rare in the world's languages and constitute marked and complex phenomena (Maddieson, 1984). According to Lleó, Cortés & Benet (2008) and Amengual & Chamorro (2015), this can explain why mid vowels in Catalan and Galician, for example, are particularly susceptible to the influence of Spanish with its unmarked 5-vowel system. Consistent with this explanation, there is widespread evidence from infants and adults for a perceptual bias favouring peripheral vowels (e.g., Nishi, Strange, Akahane-Yamada, Kubi & Trent-Brown, 2008; Polka & Bohn, 1996). In their Natural Referent Vowel framework, Polka and Bohn (2003, 2011) explain this bias on the basis of the converging formant frequencies in these vowels. This, in turn, results in acoustic energy being focused into a narrower spectral region, making peripheral vowels more salient and robust than non-peripheral ones. In what follows, we will first provide details of the sociolinguistic background of Galician. Subsequently, details of previous phonetic studies will be presented that have investigated mid-vowels contrasts in Galician.

Galician is an Ibero-Romance language, typologically closely related to Portuguese, that is spoken as a main language by 1,302,482 speakers (Monteagudo, Loredo & Vázquez, 2016: 64) in the autonomous community of Galicia in north-western Spain. It has been in long-term contact with Castilian Spanish since medieval times, with Spanish historically being the language of political, cultural and economic elites, and Galician a stigmatised low-prestige variety (Ramallo, 2007). During the Franco dictatorship, the suppression of Galician was intensified and resulted in a lack of transmission of the language in wide sections of society, in particular in urban areas, such as Vigo or A Coruña. Since Spain's transition to democracy in the late 1970's, this situation has changed substantially, with Galician recognised as an official language alongside Spanish, and policies introduced that promote and enhance Galician language use, e.g. as a medium of education (Turell, 2001; Ramallo, 2007). Although the number of Galician speakers has continued to decrease overall (Ramallo, 2017a), especially in urban areas, the inclusion of the Galician language in spaces that were traditionally occupied by Spanish, such as education, has led to the emergence of Galician *new speakers*, so-called *neofalantes* (O'Rourke, 2018; O'Rourke & Ramallo, 2013, 2015; Ramallo, 2007). *Neofalantes* are individuals, typically from urban backgrounds, who were initially raised speaking only Spanish, but at some point in their lives made a conscious decision to become Galician speakers for ideological reasons (O'Rourke, 2018; O'Rourke & Ramallo, 2013, 2015). This switch then leads to a change in language dominance with Galician used as the predominant, if not exclusive, language of everyday interactions, a change that is facilitated by the high level of mutual intelligibility between the two languages. Nevertheless, there are tensions between traditional Galician speakers and *neofalantes* with the latter commonly characterised as using 'inauthentic' Galician that is too much influenced by Spanish (O'Rourke & Ramallo, 2013).

Two previous acoustic studies have examined mid-vowel productions in different groups of Galician-Spanish bilinguals (but see also González González and Regueira Fernández (1994) for the first acoustic description of Galician vowels in stressed position and Aguete Cajiao (2017) for a perception study of mid vowel contrasts). The first, Amengual & Chamorro (2015), assessed the perception and production of Galician /e-ɛ/ and /o-ɔ/ in two groups of bilinguals from Vigo and Santiago de Compostela: (1) Spanish-dominant bilinguals, and (2) Galician-dominant bilinguals. While all participants had early experience with both languages (i.e. <1.5 years) and used them on a daily basis, the Spanish-dominant group reported earlier experience with Spanish and later experience with Galician than the Galician-dominant group as well as lower Galician usage patterns and a less native-like Galician accent, based on self-ratings. The results of a forced-choice identification task and an AX discrimination task revealed a robust category distinction on both mid-vowel contrasts for the Galician-dominant bilinguals, but not the Spanish-dominant bilinguals. Moreover, while both sets of bilinguals produced a contrast between /o/ and /ɔ/ in a reading-aloud task, only the Galician-dominant bilinguals also distinguished /e/ and /ɛ/ in production with the Spanish-dominant bilinguals neutralising this contrast completely.

Tomé Lourido & Evans (2015, 2018), in turn, examined the perception and production of the Galician mid-vowel contrasts, alongside two additional Galician-specific patterns, i.e. the /s-ʃ/ contrast and the production of unstressed word-final vowels, in three groups of Galician-Spanish bilinguals: (1) Spanish-dominant bilinguals, who were raised in Spanish-speaking homes and predominantly use Spanish in everyday interactions, (2) Galician-dominant bilinguals, who were raised in Galician-speaking homes and have always used Galician as their main language of everyday interactions (3), and *neofalantes*, who were initially raised in Spanish, but switched to Galician in adolescence for ideological reasons, since then using it as their predominant language. The results revealed maintenance of all Galician-specific categories by the Galician-dominant bilinguals, and consistent absence of these in the Spanish-dominant bilinguals. The *neofalantes*, in turn, whilst adopting Galician-specific patterns for word-final vowels, did not differ from the Spanish-dominant group on the other two variables. Thus, most importantly for the present study, only the Galician-dominant bilinguals distinguished the mid-vowel contrasts, while the Spanish-dominant bilinguals and the *neofalantes* neutralised them completely.

1.4. The present study

The present study aimed to extend this work in a number of ways. First, it sought to contribute to a better understanding of how differences in linguistic experience can affect vowel productions. To that end, it assessed the mid-vowel productions of three groups of Galician-Spanish bilinguals: (1) Spanish-dominant (SD) bilinguals who were raised in Spanish-speaking homes, learnt Galician in school, and mainly use Spanish in everyday interactions, (2) Galician-dominant (GD) bilinguals who were raised in Galician-speaking homes, learnt Spanish via mainstream education, and mainly use Galician in everyday interactions, and (3) Dual switch (DS) bilinguals who had early experience with Galician in the home, predominantly used Spanish upon school entry, but in adolescence/ adulthood switched to Galician for ideological reasons. Note that the latter group is similar to neofalantes, as described in the previous section, in that they also made a conscious choice to switch from Spanish to Galician in adolescence/ adulthood. However, unlike neofalantes, DS bilinguals had previously had early experience with Galician in the home. Based on previous work, which suggests that early linguistic experience is a prerequisite for the acquisition of Galician mid-vowel contrasts (Amengual & Chamorro, 2015; Tomé Lourido & Evans, 2015, 2018), we hypothesised that the SD bilinguals did not acquire them in the first place as children and would hence neutralise Galician mid vowels in production. In contrast, we predicted that the GD and DS bilinguals acquired the contrasts in childhood, provided the early input they received inside and outside the home was of sufficient quality and quantity, and consistent (Amengual, 2012; Cortés et al., 2018). However, the DS bilinguals may have subsequently lost the contrasts due to predominant use of Spanish upon school entry and, in line with Tomé Lourido & Evans' (2015, 2018) findings for

neofalantes, may not have been able to (re)learn them in adolescence/ adulthood. The GD bilinguals, on the other hand, due to their continuous high use of Galician, were hypothesised to maintain the contrasts, consistent with Amengual & Chamorro's (2015) and Tomé Lourido & Evans' (2015, 2018) findings.

Second, this study is the first to examine how Galician-Spanish bilinguals produce the Spanish mid vowels /e/ and /o/, and how they interact with Galician mid-vowel categories. According to descriptive reports, these vowels occupy an area of the vowel space that falls in between the mid-close and mid-open Galician categories (Vidal Figueroa, 1997); however, this has not been verified experimentally thus far. We aimed to elucidate this matter by assessing whether differences in linguistic experience affect the production of Spanish mid vowels and the extent to which they are distinct from Galician ones. We predicted that bilinguals without early experience with Galician, i.e. SD bilinguals, would not only neutralise the Galician contrasts, but also produce Spanish /e/ and /o/ with identical phonetic distributions, resulting in two sets of three-way cross-linguistic mergers. Bilinguals with early Galician language experience, in contrast, were predicted to have separate Spanish categories, potentially even in the absence of contrasts in Galician (cf. Simonet, 2011, for similar patterns in Catalan-Spanish bilinguals). Where contrasts are maintained, Spanish mid vowels may overlap with both mid-close and mid-open vowels in Galician, or be entirely separate, depending on the extent of acoustic difference. Alternatively, GD bilinguals may not have separate Spanish categories at all, but instead exhibit two acoustic distributions in the front and back vowel space of Spanish, as a result of transfer from Galician.

Finally, the study aimed to investigate the stability of Galician and Spanish mid vowel categories in contexts of dual language activation and switching. Previous work on phonetic code switching largely provided evidence for cross-linguistic interactions in switched contexts, albeit with varying directionality (Antoniou et al., 2011; Bullock & Toribio, 2009; Olson, 2013; Piccinini & Arvaniti, 2015; Simonet, 2014). Accordingly, we hypothesised that the Galician mid vowel contrasts were more likely to be maintained in unilingual settings than during language switching, as the latter condition may enhance cognitive demands and make inhibition of non-target items more difficult (Grosjean, 2001).

2.0 Methods

2.1. Design

The present study investigated the production of Galician and Spanish front and back vowel categories by three groups of Galician-Spanish bilinguals differing in linguistic experience. Data collection involved a cued picture naming task that aimed to elicit Galician and Spanish target words with the relevant mid vowel categories. The task had three conditions so as to determine the effect of language switching: (1) a unilingual Spanish condition, (2) a unilingual Galician condition, and (3) a bilingual condition in which words from both languages were elicited alternately via pictures. The target vowels were subsequently extracted from the productions and analysed acoustically.

2.2 Participants

A total of 28 Galician-Spanish bilinguals (12 males and 16 females) participated in the study. They were resident in the south-western Galician city of Vigo or surrounding areas, and had spent all or most of their formative years there. At the time of the study, they were aged between 26 and 47 years (mean: 39.14 years; SD: 4.1), and their only native languages were Spanish and/ or Galician. All participants were fluent speakers of both languages, as assessed conversationally by the experimenters collecting the data, both proficient Galician-Spanish bilinguals. None reported any medical conditions or sensory difficulties that could have interfered with the experimental process.

Each participant completed a language background questionnaire that aimed to capture their past and present experience with the two languages. This included their age of onset of L1 and L2 learning, any significant changes in input and language use over time, current language use patterns, as well as general language and social background questions. To determine their language use patterns, the participants were asked to indicate on a scale ranging from 'always' to 'never' how often they used Galician in significant domains (social relationships and environments). Based on the responses to the questionnaire, they were assigned to one of three groups, matched in age ($F(2,27)= 1.086$, $p= .353$): (1) Spanish-dominant bilinguals ($n= 10$), (2) Galician-dominant bilinguals ($n=8$) and (2) Dual Switch bilinguals ($n= 10$).

The SD participants were raised in entirely Spanish-speaking homes, and reported acquiring Galician via mainstream education (mean age of first exposure: 7.2 years; SD: 2.8). They reported Spanish as their dominant language in terms of proficiency, and mostly used Spanish in their daily lives. Table 1 (top) shows that their regular use of Galician in significant domains is relatively restricted, with combined responses for 'always' and 'often' ranging between 0% and 36.4%.

The GD bilinguals, in turn, were raised in entirely Galician-speaking homes, and reported acquiring Spanish via mainstream education (mean age of first exposure: 4.25 years; SD: 1.04) or being exposed to Spanish outside the home (e.g., media, environment, etc.). They reported Galician as their dominant language in terms of proficiency throughout life, and predominantly used Galician in their daily lives. Table 2 (middle) shows that they always or often use Galician in significant domains (average: 87.42% of instances, SD: 15.25).

Note to Publisher: Insert Table 1 about here

Finally, unlike *neofalantes* in Tomé Lourido & Evans (2015, 2018), the DS bilinguals all had early experience with Galician in the home. However, their regular use of Galician at home varied considerably. Thus, some were raised in a *one person-one language* setting (de Houwer, 2009), while others were addressed in Spanish by one parent, and in Spanish and Galician by the other. Two participants (DS-5 and DS-8) reported regularly overhearing their parents speaking Galician to each other, but mainly being addressed in Spanish themselves; finally, two participants (DS-7 and DS-10), reported Galician as the only language used in the home by both parents.

The DS bilinguals' language use patterns changed when they entered mainstream education in Spanish. This resulted in virtually exclusive use of Spanish in school contexts, despite the Royal Decree regulating the incorporation of Galician into schools (Real Decreto, 1979), and as a consequence reduced opportunities to use Galician. Participants who were previously dominant in Galician thus became dominant in Spanish. For participants who had already heard more Spanish than Galician in the home, the change in language use patterns due to mainstream education in Spanish was less pronounced[1].

The DS bilinguals' language use patterns changed again in late adolescence/ adulthood (mean age: 20.5 years, SD: 5.1) when they decided to switch to Galician for ideological reasons. These individuals reported identifying strongly with Galician culture and society, and wanting to give expression to this allegiance through linguistic means (as with *neofalantes*). For all participants,

[1] We acknowledge that not all participants in the DS group may have undergone a complete switch in language dominance when entering mainstream education, and hence the label 'dual switch' needs to be understood broadly. All DS participants exhibited a change in their linguistic environment when entering mainstream education in that they experienced reduced input in Galician, and they all again changed their language use patterns when opting to use Galician instead of Spanish in adolescence and adulthood.

this involved a change of language with close family members and/ or friends, and resulted in Galician becoming their main language in everyday interactions. Table 1 (bottom) shows that the DS participants' current use of Galician is high in significant domains, with Galician being used 'always' or 'often' on an average in 85.2% of instances (SD: 16.6), and hence much like that of the GD bilinguals.

2.3 Experimental materials

To elicit productions of the Galician mid vowel contrasts /e-ɛ/ and /o-ɔ/ and the Spanish mid vowels /e/ and /o/, a cued picture-naming task was conducted in which participants were recorded naming pictures displayed on a computer screen. The target materials included 5 (words) × 6 vowels = 30 words (cf. Table 2). These were carefully selected following piloting on a larger set of words to ensure they were unambiguous in terms of expected pronunciations (Regueira, 2017), dialectal variation and imageability. All target words were nouns or numerals. We aimed to include only high frequency items, but this proved impossible in combination with our other requirements. Lexical frequency hence varied somewhat across items (GAL frequency order mean: 10,767 (SD: 11,626); SPAN frequency order mean: 11,563 (SD: 24,364)), although there was no difference in frequency across the two languages ($t(28)= -.12$, $p=.905$; for Galician frequency, see Centro Ramón Piñeiro (CRP), 2017; for Spanish frequency, see Real Academia Española (RAE), 2017).

All target vowels were embedded in the stressed first syllable of bisyllabic words, and occurred in the prosodic environment ˈ(C)VC(CC)V. Due to the above-mentioned constraints, we were unable to match the flanking consonants closely in terms of phonetic context; however, this was factored into our statistical model through the use of item as a random factor (see below for details).

Note to Publisher: Insert Table 2 about here

In addition to the target items, filler words that did not contain the target vowels were used in the picture-naming task (15 in the unilingual Spanish condition, 14 in the unilingual Galician condition, and 29 in the switched condition). This was done so as to distract from the mid vowel contrasts as they constitute popular stereotypes and are known to many native Galicians (Tomé Lourido, 2018). All experimental items were represented by black and white line drawings, and mostly taken from Snodgrass & Vanderwart (1980).

To determine the effect of language switching, the cued picture-naming task encompassed three experimental conditions, each containing target and filler items: (1) a unilingual Galician condition; (2) a unilingual Spanish condition; and (3) a switched condition, in which pictures were randomly presented in Galician or Spanish. This resulted in 2 (conditions) × 4 (vowels) × 5 (words) = 40 Galician mid vowel tokens and 2 (conditions) × 2 (vowels) × 5 (words) = 20 Spanish mid vowel tokens, for a total of 1,680 across the 28 participants. Of these, 68 (i.e. 4.05%) were removed due to elicitation errors or poor recording quality. The filler words were not considered further for analysis.

2.4 Procedure

Data collection took place in individual sessions with participants being seated at a comfortable distance from a computer screen. They were informed that the study involved naming words from pictures on the screen in order to study how bilingual speakers use their two languages. The order of conditions was counterbalanced across individuals.

Each unilingual trial started with a brief conversation and verbal instructions in the respective language so as to set the participants into a monolingual Galician or monolingual Spanish mode, to the extent that this was possible with a bilingual experimenter (Grosjean, 2001). Before the switched condition, code-switching was used conversationally and to give out instructions. This was deemed appropriate since code-switching is widespread in Galicia (Acuña Ferreira, 2017) and the participants reported using code-switching themselves.

Note to Publisher: Insert Figure 1 about here

The order of presentation of tokens within each trial was randomised, so that no two trials were the same for any of the participants. In each, there was initially a brief familiarisation stage which aimed to ensure participants had understood the instructions, followed by the experimental stage. Participants were instructed to name the tokens in the language indicated next to the token picture (cf. Figure 1). The language to be selected was specified by the presence of one of two cartoon men, one dressed in blue, the colour of the Galician flag, representing the Galician language, and the other dressed in light red, representing the Spanish language. The speech productions were recorded using a Zoom H2 Handy recorder with integrated microphone, and stored as WAV files with a sampling frequency of 96 kHz and 16-bit quantisation.

2.5 Data analysis

The data were analysed using PRAAT software (Boersma and Weenink, 2010). To isolate the target vowels from neighbouring segments, waveform and spectrographic displays were examined (cf. Figure 2). Vowel onset was identified as the zero crossing of the first positive peak in the digitised waveform, alongside clearly visible formant patterns in the spectrogram. Vowel offset, in turn, was defined as the last well-formed period with a visible F2. Where the flanking consonants were nasals, intensity curves were examined alongside changes in F2 trajectories.

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The frequency of the first two formants was measured at the vowel mid-point using formant trackers, set at a frequency maximum of 5500 Hz for females and 5000 Hz for males with a dynamic range of 35 dB, and a window length of 0.025 seconds. The maximum number of formants was set to 5. None of the tokens exhibited any significant vowel-inherent spectral change, so a single measurement point was deemed appropriate. All outlier F1 and F2 automatic measurements were hand corrected when they showed mistracking. Raw Hertz values were converted to Bark (Traunmüller, 1990) to reflect perceived bandwidth differences in the human auditory system.

3.0 Results

3.1 Front vowels

Figure 3 depicts the Bark-normalised F1~F2 mean values of Galician /e/ and /ɛ/, and Spanish /e/ for each group.

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Inspection of the figure shows considerable overlap across the three vowels for all three speaker groups. To test for differences across the vowels, groups and conditions, linear mixed-effects

models were run separately in R (R Core Team, 2016) for F1 (Bark) and F2 (Bark), using all 799 tokens. In each model, we entered *vowel* (3 levels: Galician /e/ and /ɛ/ and Spanish /e/), *group* (3 levels: SD bilinguals, GD bilinguals and DS bilinguals) and *condition* (2 levels: unilingual and switched) as fixed factors, including all interactions, and *participant* and *item* as random factors with random slopes for *vowel*. Using the LmerTest function in R (Kuznetsova, Bruun, Brockhoff & Haubo Bojesen Christensen, 2016), we obtained degrees of freedom via the Satterthwaite approximation, which generated p-values. An α-level of 0.05 was used throughout for hypothesis testing.

Note to Publisher: Insert Table 3 about here

Table 3 depicts the results for the two models. On both F1 (Bark) and F2 (Bark), there was no significant main effect of *vowel*, nor was there a significant interaction involving *vowel*. The participants hence produced no difference between the two Galician front vowels, nor between the latter and their Spanish counterpart. This suggests neutralisation of the Galician contrast, and in addition a merger with Spanish /e/. This pattern not only held for the SD bilinguals, who had no early experience with Galician, but also for the DS bilinguals and, surprisingly, the GD bilinguals.

Note that the model did reveal significant between-group differences in F1 (Bark). However, this affected all vowels equally (cf. Figure 4), and when followed up in pairwise comparisons, only showed significantly higher F1 (Bark) values for the GD bilinguals than the SD bilinguals (p= .00676). This result could be a reflection of the normalisation process, as there are greater numbers of females in the GD group than the SD group. Finally, the results revealed no effect of *condition*, suggesting that alternating language during picture naming was inconsequential for the participants' vowel productions.

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3.2 Back vowels

Figure 5 depicts the Bark-normalised F1~F2 mean values of Galician /o/ and /ɔ/, and Spanish /o/ for each group.

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As with the front vowels, the participants' productions exhibited considerable overlap across the three back vowel categories for each speaker group. To test for differences on the back vowels, we ran another set of linear mixed-effects models, using all 813 tokens, again separately for F1 (Bark) and F2 (Bark), with *vowel*, *group* and *condition* as fixed factors, including interactions, and *participant* and *item* as random factors with random slopes for *vowel*.

Note to Publisher: Insert Table 4 about here

The results revealed no significant effect of *vowel* on either F1 (Bark) and F2 (Bark), nor was there a significant interaction involving *vowel*. The participants hence produced no difference between the two Galician back vowels, nor between the latter and their Spanish counterpart. This suggests neutralisation of Galician /o-ɔ/, and in addition a merger with Spanish /o/. This pattern not only held for the SD bilinguals, but also for the DS bilinguals and, again surprisingly, the GD bilinguals.

As with the front vowels, there was a significant effect of *group* for F1 (Bark), which again could be due to differences in gender distribution across the groups. However, as the boxplots in Figure 6 show, the between-group differences are consistent across the vowels. Follow-up models revealed that the F1 (Bark) of the GD bilinguals was significantly higher than that of the

SD bilinguals (p=.00873) and the DS bilinguals (p= .00867), but not between the latter two groups (p= .858). Finally, as with the front vowels, the results for the back vowels revealed no effect of *condition*, and hence unilingual and switched productions did not exhibit any differences.

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3.3 Individual variation

The results presented thus far are based on group data. However, in view of the variability in linguistic experience across participants and in order to uncover mapping patterns within and across languages, we also wanted to investigate individual variation in the participants' vowel productions. To this end, we followed Amengual's (2016) and Amengual & Chamorro's (2015) approach and calculated Pillai scores from each participant. Pillai scores are a measure for degree of merger, and have been used widely to examine vowel contrasts (Hay, Warren & Drager, 2006; Sloos, 2013). They are generated as part of a multivariate analysis of variance (MANOVA) and reveal the extent to which one variance can be predicted by another. For the purposes of this study, separate Pillai scores were calculated for each of the six vowel contrasts. Since the group analyses revealed no effect of *condition*, data from the unilingual and switched conditions were pooled. Following Sloos' (2013) and Amengual & Chamorro's (2015) approach, we considered Pillai scores with a p-value of <0.05 as indicating distinction, and Pillai scores with a p-value of >0.05 as indicating neutralisation. Tables 5 and 6 depict the results for the front and back vowel contrasts, respectively.

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Inspection of the tables shows widespread neutralisation, confirming the results from the group analyses, with the majority of participants exhibiting a three-way cross-linguistic merger in the front and back vowel space. Nevertheless, the GD bilinguals maintained substantially more contrastivity than the bilinguals in the other two groups. Thus, on the Galician contrasts, two of the eight GD bilinguals differentiated /o-ɔ/ and one /e-ɛ/, with a further three showing a trend towards vowel separation for the front vowels. In contrast, across the 20 participants in the other two groups there was only one clearly maintained contrast, i.e. Galician /e-ɛ/ for SD-10, with two additional trends towards differentiation.

Where Galician contrasts were maintained, a number of interesting cross-linguistic patterns emerged. For example, in a few cases, Spanish mid vowel categories only showed a merger with one Galician category, while the other one remained distinct, resulting in a two-way mid vowel system in the front and back vowel areas. Accordingly, GD-5 appears to have a cross-linguistically merged /o/ category, but a distinct Galician /ɔ/; in contrast, GD-8 shows the reverse pattern, with a distinct Galician /o/ category but a merged category for Galician /ɔ/ and Spanish /o/. Again others, such as GD-7 on the front vowels, showed cross-linguistic overlap with both Galician categories. Theoretically, this pattern could have arisen from distinctive Galician distributions having been transferred to Spanish, in which case GD-7 would not have a separate Spanish front mid vowel category. However, inspection of her individual productions revealed that her Spanish /e/ also encompasses the area between her Galician vowels, which suggests that she has three distinct mid vowel categories in the front vowel space. Note that none of the participants exhibited three entirely distinct distributions in the front or back vowel space.

Finally, participants who did not maintain the Galician contrasts also showed some interesting cross-linguistic patterns. Thus, GD-2 who neutralised Galician /e/ and /ɛ/, differentiated both vowels from Spanish /e/, suggesting a language-specific front vowel category for Galician (for similar patterns, see also D2-7, and DS-3 for the back vowels). Similarly, where only one of the Galician categories is distinct from a Spanish one, as in the case of GD-6 for the front vowels or

DS-5 for the back vowels, this equally suggests cross-linguistic distinctiveness, but with a degree of overlap across the merged Galician category and its Spanish counterpart.

4.0 Discussion

The purpose of this study was to gain a better understanding of how linguistic experience affects bilingual speech patterns, how Galician and Spanish mid vowels relate to each other and what role language switching has in this process. To this end, we elicited Galician and Spanish mid-vowel productions in unilingual and switched conditions from three groups of Galician-Spanish bilinguals: (1) Spanish-dominant bilinguals from Spanish-speaking homes, who learnt Galician via mainstream education, but mostly used Spanish in everyday interactions, (2) Galician-dominant bilinguals from Galician-speaking homes who have continuously used Galician as their main language throughout life, and (3) Dual Switch bilinguals who had early experience with Galician, predominantly used Spanish when entering mainstream education, but switched to Galician in adolescence or adulthood for ideological reasons, since then using it as their main language of everyday interactions. The results revealed non-distinct productions of Galician /e-ɛ/ and /o-ɔ/ for all three sets of bilinguals. Moreover, they overlapped with Spanish /e/ and /o/, respectively, resulting in three-way cross-linguistic mergers in the mid-front and mid-back regions of the vowel space. While these findings held for the group results, inspection of individual variation also revealed evidence of Galician-specific realisations and cross-linguistic differentiation. Finally, the bilinguals' vowel productions in the unilingual condition did not differ from those in the switched condition. In what follows, we will discuss the implications of these findings.

To begin with, let us consider why the SD bilinguals did not produce the Galician mid vowel contrasts distinctly. These individuals were raised in Spanish-speaking homes and learnt Galician at a later stage via the education system. As such, their linguistic experience was much like that of Tomé Lourido & Evans' (2015, 2018) Spanish-dominant bilinguals who also did not distinguish Galician /e-ɛ/ and /o-ɔ/. In contrast, the Spanish-dominant bilinguals in Amengual & Chamorro (2015) managed to produce the /o-ɔ/ contrast distinctly, even though they neutralised /e-ɛ/ in production, and failed to distinguish both contrasts in perception. It is possible that these individuals were addressed in Galician from an early age, although the nature of the early input they received in the home is not specified in the paper. In any case, early experience with Galician may be a prerequisite for successful acquisition of the mid-vowel contrasts, with the robustness of language-specific features being determined by the quality and quantity of this early experience. Accordingly, only the Galician-dominant bilinguals had a consistent category boundary in Amengual & Chamorro (2015) and performed at ceiling for both vowel contrasts in a vowel identification task in Tomé Lourido & Evans (2015, 2018). Moreover, in both studies only the Galician-dominant bilinguals managed to produce both mid vowel contrasts with spectrally distinct patterns. The results for the SD bilinguals in the present study are hence in line with these findings and suggest a lack of early linguistic experience with Galician and predominant use of Spanish as the reasons for their merged mid vowel productions, although some of the explanations discussed further below may also apply.

If early experience is a critical factor in acquisition, why then did the DS and GD bilinguals not distinguish the Galician mid vowel contrasts, nor differentiate them from their Spanish counterparts? One possibility is that their experience was qualitatively and quantitatively different despite early exposure to Galician in the home. This is clearly the case for many of the DS bilinguals since alongside Galician they were also exposed to Spanish. Two, i.e. DS-5 and DS-8, were even exclusively addressed in Spanish while they overheard their parents use Galician. Accordingly, these individuals may not have heard enough exemplars of the Galician mid vowel contrasts in the input to acquire them. At the same time, the input they received in Spanish may have reinforced use of a single mid front and back vowel category. These explanations are consistent with previous studies that have shown better acquisition of language-specific patterns in settings where children are exclusively exposed to a single language in the home, rather than two (e.g., Amengual, 2017).

Limited early exposure to Galician and regular input in Spanish cannot explain the patterns of the GD bilinguals and two of the DS bilinguals, i.e. DS-7 and DS-10, however, since they were raised in Galician-only homes. Why then, with individual exceptions, did they not produce the mid vowel contrasts distinctly? After all, previous studies have shown these patterns in bilinguals with extensive early experience with Galician (Amengual & Chamorro, 2015; Tomé Lourido & Evans, 2015, 2018). One possibility is a lack of sustained use of Galician. This may have been the case for DS-7 and DS-10 since they switched their dominance to Spanish upon school entry, with Spanish the main language of education at the time. As a result, as Spanish became their dominant language, their Galician usage patterns decreased and remained low until at least late adolescence. Previous research has shown that this can adversely affect accuracy of pronunciation patterns. Mora & Nadeu (2012), for instance, showed that native Catalan speakers who had learnt Spanish after age 4-5 and used Spanish frequently, produced Catalan /ɛ/ with Spanish-influenced values, while otherwise matched Catalan speakers with low Spanish usage did not. In their study, frequent use of Spanish alongside Catalan did not lead to a complete loss of previously acquired patterns, i.e. a merger of Catalan /e/ and /ɛ/, while this could have happened here. Moreover, if this was indeed the case for the two DS bilinguals, a late switch to Galician in adolescence or adulthood together with high Galician language use did not lead to a reversal of the loss of the mid-vowel contrasts. In like manner, Tomé Lourido & Evans (2015, 2018) found that their neofalantes who, having similarly undergone a late switch to Galician for ideological reasons, also failed to differentiate Galician /e-ɛ/ and /o-ɔ/. However, unlike them, DS-7 and DS-10 could theoretically have reactivated memory traces created in early childhood. Indeed, a number of studies from international adoptees showed that speech patterns experienced early in life may be accessible in adulthood (Choi et al., 2017; Hyltenstam et al., 2009; Pierce et al., 2015, but see Pallier et al., 2003; Ventureyra et al., 2004). However, the individuals in these studies had no exposure to the childhood language at all after a short period of exposure early in life, whereas the bilinguals in the present study continuously used Galician alongside Spanish, albeit to a lesser extent. This, in turn, could have led to regular co-activation of both languages and hence continuous interaction with the dominant language (Darcy & Krüger, 2012; Mora et al., 2015), thereby superseding previously acquired representations.

While a lack of continuous use may be a credible explanation, at least in part, for the patterns of the two DS bilinguals from Galician-only homes, it cannot account for the merged contrasts in the GD bilinguals since the latter have been using Galician consistently as their main language throughout life. What then can explain their mid vowel patterns? One possibility is that lexical factors may be responsible for the findings. Thus, Amengual (2016) showed that highly proficient early Catalan-Spanish bilinguals distinguished Catalan /o/ and /ɔ/ less in cognates than in words that are lexically distinct in Catalan and Spanish. Moreover, their accuracy in a lexical decision task was also affected by cognate status, which suggests a close interaction between phonetic and lexical levels in bilinguals. Nevertheless, it is unlikely that the mergers observed here are due to our target words being cognates. First, with Galician and Spanish being typologically closely related languages that have co-existed for centuries, cognates constitute substantial portions of their lexicons. If the mid vowel contrasts were only maintained in non-cognates, they would be highly marginal phenomena. Second, there is an abundance of evidence for differentiated mid vowel productions in Galician cognates from recent studies (Amengual & Chamorro, 2015; Tomé Lourido & Evans, 2015, 2018).

A more likely explanation is that it has to do with the nature of the Galician input the participants received. Thus, Spanish-accented varieties of Galician that lack the mid vowel contrasts are associated with urban environments (O'Rourke & Ramallo, 2013, 2015). Based on impressionistic data, Vidal Figueroa (1997) distinguishes two distinct varieties of Galician in Vigo: the traditional Vigo dialect, which maintains the mid vowel contrasts, and educated urban Galician, which does not. It is likely that the participants in the present study have had significant exposure to both. Greater experience with the latter variety, including exposure as children in the home or in the neighbourhood (Cortés et al, 2018), could hence have led to

adoption of its features. In other words, bilinguals may simply not have heard enough distinctive productions of Galician /e-ɛ/ and /o-ɔ/ in everyday interactions. Moreover, it is important to consider the status of these varieties. Thus, while traditional varieties of Galician that contain the contrasts are often perceived to be 'authentic' (O'Rourke & Ramallo, 2013), they are also predominantly associated with rural areas and have been shown to receive negative social evaluations by Galician listeners (González González, et al. 2003; see also Ramallo, 2017b). In contrast, Spanish-accented varieties of Galician received positive judgements (González González, et al. 2003), despite being regarded as inauthentic by some Galician-dominant speakers (e.g. Kabatek, 2000). The Spanish-accented variety of Galician associated with urban areas has been referred to as 'New Urban Galician' and is widely used in public administration, education and the media (Dubert García, 2002; Regueira, 1999; Vidal Figueroa. 1997). Thus, even if the bilinguals with early Galician experience had initially been solely exposed to more traditional varieties of Galician that contain the mid vowel contrasts and hence acquired them - a plausible scenario since Galician was suppressed in public settings during the Franco regime when our participants' parents grew up, and has only been used in the media and in education since the 1980's (Ramallo, 2007) - it is possible that they subsequently abandoned these more traditional forms in favour of more prestigious urban ones. In the absence of detailed ethnographic data from our participants, we are, of course, unable to substantiate the role of indexical factors, but it is important to consider them alongside cognitive ones.

How then can the results for the GD bilinguals in the present study be reconciled with previous studies in which GD bilinguals distinguished the contrasts? To begin with, the disparity across studies could have arisen from methodological differences. Thus, both Amengual & Chamorro (2015) and Tomé Lourido & Evans (2015, 2018) used a reading task to obtain mid-vowel productions with the target words embedded in a sentence frame or reading passage. In contrast, we elicited our data in a cued picture naming task in the present study, in which the participants needed to activate isolated lexical representations. Moreover, the lack of contrast observed here could have been caused by the selection of different lexical items, a factor that has previously been shown to be critical for Catalan mid-vowels (Nadeu & Renwick, 2016). However, despite some variation in the items used across the studies, all three contain highly similar materials, with bisyllabic words used in virtually all instances. Moreover, there is substantial overlap in the actual items used. For example, both Amengual & Chamorro (2015) and the present study contain *neno* for /e/, *sete* and *perna* for /ɛ/, *lobo* for /o/, and *porta* and *roda* for /ɔ/. Overall, while we cannot rule out that methodological differences have, at least in part, affected the results obtained here, we contend that they are better explained by differences across the studies in participant characteristics and social settings.

Specifically, Tomé Lourido & Evans (2015, 2018) collected their data in different social and geographical settings where other norms may apply. For example, bilinguals in the Galician-dominant group came from both urban and rural areas and a variety of geographical locations. In contrast, all participants in the current study and approximately half of those in Amengual & Chamorro (2015) were from Vigo, where Galician is not widely spoken with only 19% of speakers reporting to use it as their main language (Monteagudo, Loredo & Vázquez, 2016:160). Note that while all of the participants in the present study were raised in the city, it is unclear if the same criterion was applied in Amengual & Chamorro's (2015) study, or if they also included Vigo residents who had been raised elsewhere. In any case, all three studies report that at least some GD bilinguals exhibited mid vowel mergers. Thus, despite differentiation at the group level, even in Tomé Lourido & Evans (2015, 2018) a small number of individuals had merged contrasts. Similarly, Amengual & Chamorro (2015) found that four of their 15 GD bilinguals from Vigo did not distinguish the Galician /e-ɛ/ contrast and one did not distinguish the /o-ɔ/ contrast. At the same time, one of the eight GD bilinguals in the present study produced the front vowel contrast and two the back vowel contrast. The present study hence primarily differs from previous ones in *extent*, in that it is the first to document mid vowel mergers at the group level. What the studies together suggest then is that extensive exposure to traditional Galician varieties, such as those reported for Tomé-Lourido & Evans' (2018) rural

GD participants, coupled with little use of Spanish, is likely to lead to consistent acquisition and maintenance of mid vowel contrasts. Conversely, bilinguals who are exposed to Galician varieties that vary in terms of whether they contain the contrasts or not, as in Vigo where Spanish-accented varieties are common, are likely to acquire merged categories, or if they do differentiate the mid vowels, exhibit instability, even when growing up in entirely Galician-speaking homes.

Beyond Galician vowels, this study also contributed data from Spanish /e/ and /o/ productions by the three groups of bilinguals so as to explore their relation to Galician categories. On the whole, the results showed that the Spanish vowels overlapped acoustically with their Galician counterparts, thereby forming three-way cross-linguistic mergers in the front and back portions of the vowel space. Moreover, neutralisation of the Spanish and Galician mid vowels not only occurred in switched contexts, where cognitive demands are higher and interaction is more likely (Grosjean, 2001; Olson, 2013; Simonet, 2014), but also in unilingual contexts. These results could suggest assimilation of Galician vowels to Spanish categories, and hence cross-linguistic transfer, in line with models of bilingual speech development, notably the SLM (Flege, 1995; Flege et al., 2003) and the PAM/ PAM-L2 (Best, 1995; Best & Tyler, 2007). However, alternatively, and consistent with the explanations given above, the observed overlap in mid vowels across languages may be due to the location of mid vowel categories in urban varieties of Galician, which, in turn, are a product of language contact. At the same time, our data also showed some evidence of individual differentiation between Galician and Spanish mid vowels. As predicted, this was more common for bilinguals who maintained the Galician mid vowel contrasts. However, we also found instances of cross-linguistic differentiation in the presence of merged Galician contrasts, as previously shown for Catalan-Spanish bilinguals (Simonet, 2011). Overall, the mid vowel productions in the present study occupied a large portion of the acoustic space, allowing for a fair amount of variation. Future research is needed to determine whether realisations in particular parts of the mid vowel space are perceived as more or less 'Spanish-sounding'.

5.0 Conclusion

The present study examined the Galician and Spanish mid vowel productions of three groups of Galician-Spanish bilinguals who differ in their linguistic experience: SD bilinguals, GD bilinguals and DS bilinguals. Our results show that not only the SD bilinguals neutralised the Galician mid vowel contrasts /e-ɛ/ and /o-ɔ/ in production, as previous accounts have demonstrated (Amengual & Chamorro, 2015; Tomé Lourido & Evans, 2015, 2018), but also the DS bilinguals, and, unexpectedly, the GD bilinguals. As such, this study is the first to document widespread mergers of Galician mid-vowels in bilinguals who were raised in Galician-speaking homes and use Galician as their main language in everyday interactions. Moreover, it showed for the first time that the Spanish mid vowels /e/ and /o/ occupy the same acoustic space as the merged Galician vowels, and that these patterns hold both in unilingual and switched conditions. Together, the findings suggest that while early linguistic experience and continuous language use may be critical for the acquisition and maintenance of certain language-specific speech patterns, explanations need to go beyond cognitive factors and in particular consider the role of the input and socio-indexical values.

On the basis of the data obtained here, it has only been possible to speculate about some of the relevant factors. Future research is hence needed that extends the work reported here and tests these systematically. For example, we do not yet know how mid vowel contrasts develop in different groups of Galician-Spanish bilingual children and under what circumstances acquisition may be accelerated or delayed. To answer these questions, we need to have a better understanding of the precise nature of the input that children receive in the home, in particular in urban areas, but in the light of recent findings from the Catalan context (Cortés et al., 2018), also what role the predominant language of the environment plays. Moreover, using sociolinguistic and ethnographic methods, further research is needed that examines the factors that facilitate or hinder the maintenance of the contrasts, such as attitudes to the varieties or

degrees of exposure to them throughout the lifespan. By carrying out such research, we may get a step closer to understanding the complexities involved in the development of bilingual sound systems.

Reference List

Acuña Ferreira, A.V. (2017). Code-switching and emotions display in Spanish/Galician bilingual conversation. *Text and Talk, 37*, 47–69.

Aguete Cajiao, A. (2017). Factores externos na variación do vocalismo galego. Estudo perceptivo. In X. L. Regueira, & E. Fernández Rei (Eds.), *Estudos sobre o cambio lingüístico no galego actual* (pp. 63–97). Santiago de Compostela: Consello da Cultura Galega.

Ahn, S., Chang, C. B., DeKeyser R., & Lee-Ellis, S. (2017). Age effects in first language attrition: Speech perception by Korean-English bilinguals. *Language Learning, 67*, 694–733.

Amengual M (2012): Interlingual influence in bilingual speech: cognate status effects in a continuum of bilingualism. *Bilingualism: Language and Cognition*, 15, 517–530.

Amengual, M. (2016). Cross-linguistic influence in the bilingual mental lexicon: Evidence of cognate effects in the phonetic production and processing of a vowel contrast. *Frontiers in Psychology, 7*, 617.

Amengual, M. (2017). Type of bilingualism and its effect on the acoustic realization of allophonic variants: Early sequential and simultaneous bilinguals. *International Journal of Bilingualism*, doi: 10.1177/1367006917741364.

Amengual, M., & Chamorro, P. (2015). The effects of language dominance in the perception and production of the Galician mid vowel contrasts. *Phonetica, 72*, 207-236.

Antoniou, M., Best, C., Tyler, M., & Kroos, C. (2011). Inter-language interference in VOT production by L2-dominant bilinguals: Asymmetries in phonetic codeswitching. *Journal of Phonetics, 39*, 558–570.

Aoyama, K., Flege, J.E., Guion, S., Akahane-Yamada, R., & Yamada, T. (2004). Perceived phonetic dissimilarity and L2 speech learning: The case of Japanese /r/ and English /l/ and /r/. *Journal of Phonetics, 32*, 233–250.

Au, T. K. F., Oh, J. S., Knightly, L. M., Jun, S. A., & Romo, L. F. (2008). Salvaging a childhood language. *Journal of Memory and Language, 58*, 998–1011.

Au, T. K., Knightly, L.M., Jun, S-A, & Oh, J.S. (2002). Overhearing a language during childhood. *Psychological Science, 13*, 238–243.

Bergmann, C., Nota, A., Sprenger, S.A., & Schmid, M.S. (2016). L2 immersion causes non-native-like L1 pronunciation in German attriters. *Journal of Phonetics, 58*, 71–86.

Best, C.T. (1995). A direct realist perspective on cross-language speech perception. In Strange, W (Ed.), *Speech perception and linguistic experience: Issues in cross-language research* (pp. 171–204). Timonium, York Press.

Best, C. T., & Tyler, M. D. (2007). Nonnative and second-language speech perception: Commonalities and complementarities. In M. J. Munro & O.-S. Bohn (Eds.), *Second language speech learning: The role of language experience in speech perception and production* (pp. 13–34). Amsterdam: John Benjamins.

Birdsong, D. (2007). Native-like pronunciation among late learners of French as a second language. In Bohn, O.-S. & Munro, M. (Eds*.), Language experience in second language speech learning. In honor of James Emil Flege* (pp. 99-116). Amsterdam/ Philadelphia: John Benjamins.

Boersma, P., & Weenink, D. (2010). PRAAT: doing phonetics by computer (version 5.1.31). Institute of Phonetic Sciences, University of Amsterdam, online: http://www.fon.hum.uva.nl/praat <retrieved 5 April 2010>.

Bongaerts, T., Mennen, S., & Slik, F. van der (2000). Authenticity of pronunciation in naturalistic second language acquisition: The case of very advanced late learners of Dutch as a second language. *Studia Linguistica, 54*, 298-308.

Bosch, L., & Sebastián-Gallés, N. (2003). Simultaneous bilingualism and the perception of a language-specific vowel contrast in the first year of life. *Language and Speech, 46*, 217–243.

Bullock, B. E., & Toribio, A. J. (2009). Trying to hit a moving target: On the sociophonetics of code–switching. In Isurin, L. Winford, D. & de Bot, K. (Eds.), *Interdisciplinary approaches to code-switching* (pp. 189–206). Amsterdam: John Benjamins.
Chang, C. B. (2012). Rapid and multifaceted effects of second-language learning on first-language speech production. *Journal of Phonetics, 40,* 249–268.
Chang, C.B. (2013). A novelty effect in phonetic drift of the native language. *Journal of Phonetics, 41,* 520–533.
Chang, C. B., Yao, Y., Haynes, E. F., & Rhodes, R. (2011). Production of phonetic and phonological contrast by heritage speakers of Mandarin. *Journal of the Acoustical Society of America, 129,* 3964–3980.
Choi, J., Cutler, A., & Broersma, M. (2017). Early development of abstract language knowledge: Evidence from perception–production transfer of birth-language memory. *Royal Society Open Science, 4,* 160660, http://dx.doi.org/10.1098/rsos.160660.
Centro Ramón Piñeiro para a investigación en humanidades: Corpus de Referencia do Galego Actual (CORGA) [3.0] - <http://corpus.cirp.gal/corga> [08/12/2017]
Colantoni, L., Steele, J., & Escudero, P. (2015). *Second language speech: Theory and practice*. Cambridge: Cambridge University Press.
Cortés, S., Lleó, C., & Benet, A. (2018). Weighing factors responsible for the production of the Catalan vowel /ɛ/ versus /e/ contrast in three districts of Barcelona. *International Journal of Bilingualism*, http://journals.sagepub.com/doi/10.1177/1367006918781058.
Darcy, I., & Krüger, F. (2012). Vowel perception and production in Turkish children acquiring L2 German. *Journal of Phonetics, 40,* 568–581.
De Houwer, A. (2009). *Bilingual first language acquisition*. Bristol: Multilingual Matters.
De Leeuw, E., Mennen, I., & Scobbie, J.M. (2013). Dynamic systems, maturational constraints and L1 phonetic attrition. *International Journal of Bilingualism, 17,* 683–700.
De Leeuw, E., Schmid, M.S., & Mennen, I. (2010). The effects of contact on native language pronunciation in an L2 migrant setting. *Bilingualism: Language and Cognition, 13,* 33–40.
De Leeuw, E., Tusha, A., & Schmid, M.S. (2017). Individual phonological attrition in Albanian–English late bilinguals. *Bilingualism: Language and Cognition,* doi:10.1017/S1366728917000025
Dmitrieva, O., Jongman, A., & Sereno, J. (2010). Phonological neutralization by native and non-native speakers: The case of Russian final devoicing. *Journal of Phonetics, 38,* 483–492.
Dubert García, F. (2002). Os sociolectos galegos. *Cadernos de Lingua,* 24, 5–27.
Fennell, C.T., Sin-Mei Tsui, A., & Hudon, T.M. (2016). Speech perception in simultaneously bilingual infants. In Nicoladis, E. & Montanari, S. (Eds.), *Bilingualism across the lifespan: Factors moderating language proficiency* (pp. 43–62). Berlin: de Gruyter.
Flege, J.E. (1995). Second language speech learning: theory, findings and problems. In Strange, W. (Ed.), *Speech perception and linguistic experience: Issues in cross-language research* (pp. 229–273). Timonium, York Press.
Flege, J.E., Frieda, E.M., & Nozawa, T. (1997). Amount of native-language (L1) use affects the pronunciation of an L2. *Journal of Phonetics, 25,* 169–186.
Flege, J.E., Munro, M., & MacKay, I.R.A. (1995). Factors affecting strength of perceived foreign accent in a second language. *Journal of the Acoustical Society of America, 97,* 3125–3134.
Flege, J.E. Schirru, C., & MacKay, I.R.A. (2003). Interaction between the native and second language phonetic subsystems. *Speech Communication, 40,* 467–491.
González González, M., & Regueira Fernández, X. L. (1994). Estudio acústico das vocais tónicas galegas en posición fonética normal. *Actas Do Congreso Internacional de Lingüística E Filoloxía Románica,* 141–179.
González González, M., Rodríguez Neira, M., Dosil Maceira, A., Pérez Vilariño, J., Real Deus, E., Casares Berg, H., Fernández Salgado, A., Loredo Gutiérrez, X., Pereiro Rozas, A. X. & Suárez Fernández, I. (2003). *O galego segundo a mocidade*. A Coruña: Real Academia Galega, Seminario de sociolingüística.

Green, D.W. (1998). Mental control of the bilingual lexico-semantic system. *Language and Cognition, 1*, 67–81.
Grosjean, F. (2001). The bilingual's language modes. In Nicol, J. (Ed.), *One mind, two languages: bilingual language processing* (pp. 1–22). Oxford: Blackwell.
Grosjean, F., & Miller, J. L. (1994). Going in and out of languages: An example of bilingual flexibility. *Psychological Science, 5*, 201–206.
Guion, S. (2003). The vowel systems of Quichua–Spanish bilinguals. *Phonetica, 60*, 98–128.
Harrington, J. (2006). An acoustic analysis of 'happy-tensing' in the Queen's Christmas broadcasts, *Journal of Phonetics, 34*, 439–457.
Harrington, J., Palethorpe, S., & Watson, C.I. (2000). Does the Queen speak the Queen's English? *Nature, 408*, 927–928.
Hay, J., Warren, P., & Drager, K. (2006): Factors influencing speech perception in the context of a merger-in-progress. *Journal of Phonetics, 34*, 458–484.
Hyltenstam, K., Bylund, E., Abrahamsson, N., & Park, H. S. (2009). Dominant-language replacement: The case of international adoptees. *Bilingualism: Language and Cognition, 12*, 121–140.
Instituto Galego de Estatística (2013). Enquisa estrutural a fogares. Coñecemento e uso do galego. Persoas que saben falar galego 2013. Santiago: Instituto Galego de Estatística.
Jacobs, A., Fricke, M., & Kroll, J. F. (2016). Cross-Language activation begins during speech planning and extends into second language speech. *Language Learning*, 66, 324-353.
Kupisch, T., Barton, D., Hailer, K., Klaschik, E., Stangen, I., Lein, T., & Weijer, J. van de (2014). Foreign accent in adult simultaneous bilinguals. *Heritage Language Journal, 11*, 123–150.
Kuznetsova, A., Bruun Brockhoff, P., & Haubo Bojesen Christensen, R. (2016). lmerTest: Tests in Linear Mixed Effects Models. R package version 2.0-32. https://CRAN.R-project.org/package=lmerTest
Lenneberg, E. (1967). *Biological foundations of language*. New York, NY: Wiley.
Lleó, C., Cortés, S., & Benet, A. (2008). Contact-induced phonological changes in the Catalan spoken in Barcelona. In Siemund, P. & Kintana, N. (Eds.), *Language contact and contact languages* (pp. 185–212). Amsterdam, John Benjamins.
Long, M. (1990). Maturational constraints on language development. *Studies in Second Language Acquisition, 12*, 251–285.
MacLeod, A.A.N., Stoel-Gammon, C., & Wassink, A.B. (2009). Production of high vowels in Canadian English and Canadian French: A comparison of early bilingual and monolingual speakers. *Journal of Phonetics, 37*, 374–387.
Maddieson, I. (1984). *Patterns of sounds*. Cambridge: Cambridge University Press.
Mayr, R., & Montanari, S. (2015). Cross-linguistic interaction in trilingual phonological development: The role of the input in the acquisition of the voicing contrast. *Journal of Child Language, 42*, 1006–1035.
Mayr, R., Price, S., & Mennen, I. (2012). First language attrition in the speech of Dutch–English bilinguals: The case of monozygotic twin sisters. *Bilingualism: Language and Cognition, 15*, 687–700.
Mayr, R., & Siddika, A. (2018). Inter-generational transmission in a minority language setting: Stop consonant production by Bangladeshi heritage children and adults. *International Journal of Bilingualism*, 22, 255-284.
McCarthy, K., Evans, B., & Mahon, M. (2013). Acquiring a second language in an immigrant community: The production of Sylheti and English stops and vowels by London-Bengali speakers. *Journal of Phonetics, 41*, 344–358.
McCarthy, K., Mahon, M., Rosen, S., & Evans, B. (2014). Speech perception and production by sequential bilingual children: A longitudinal study of voice onset time acquisition. *Child Development, 85*, 1965–1980.
Mennen, I. (2004). Bi-directional interference in the intonation of Dutch speakers of Greek. *Journal of Phonetics, 32*, 543–563.
Monteagudo, H., Loredo, X., & Vázquez, M. (2016). *Lingua e sociedade en Galicia. A evolución sociolingüística 1992-2013*. A Coruña: Real Academia Galega.

Mora, J. C., Keidel, J. L., & Flege, J. E. (2015). Effects of Spanish use on the production of Catalan vowels by early Spanish-Catalan bilinguals. In Romero, J., & Riero, M. (Eds.), *The phonetics-phonology interface: Representations and methodologies* (pp. 33–53). Amsterdam: John Benjamins.

Mora, J.C., & Nadeu, M. (2012). L2 effects on the perception and production of a native vowel contrast in early bilinguals. *International Journal of Bilingualism, 16*, 484–500.

Muldner, K., Hoiting, L., Sanger, L., Blumenfeld, L., & Toivonen, I. (2017). The phonetics of code-switched vowels. *International Journal of Bilingualism*, doi: 10.1177/1367006917709093.

Nadeu, M., & Renwick, M. E. L. (2016). Variation in the lexical distribution and implementation of phonetically similar phonemes in Catalan. *Journal of Phonetics*, 58, 22–47.

Narayan, C., Werker, J.F., & Beddor, P. (2010). The interaction between acoustic salience and language experience in developmental speech perception: Evidence from nasal place discrimination. *Developmental Science, 13*, 407–420.

Nishi, K., Strange, W., Akahane-Yamada, R., Kubi,R., & Trent-Brown, S.A. (2008). Acoustic and perceptual similarity of Japanese and American English vowels. *Journal of the Acoustical Society of America, 124,* 576–588.

Norris, D., McQueen, J.M., & Cutler, A. (2003). Perceptual learning in speech. *Cognitive Psychology, 47*, 204–238,

Oh, J., Jun, S., Knightly, L., & Au, T. (2003). Holding on to childhood language memory. *Cognition, 86*, 53–64.

Olson, D. J. (2013). Bilingual language switching and selection at the phonetic level: Asymmetrical transfer in VOT production. *Journal of Phonetics, 41,* 407–420.

O'Rourke, B. (2018). Just use it! Linguistic conversion and identities of resistance amongst Galician new speakers. *Journal of Multilingual and Multicultural Development,* 39, 407-418.

O'Rourke, B., & Ramallo, F. (2013). Competing ideologies of linguistic authority amongst new speakers in contemporary Galicia. *Language in Society, 42*, 287–305.

O'Rourke, B., & Ramallo, F. (2015). Neofalantes as an active minority: Understanding language practices and motivations for change amongst new speakers of Galician. *International Journal of the Sociology of Language, 231*, 147–165.

Pallier, C., Bosch, L., & Sebastián-Gallés, N., N. (1997). A limit on behavioral plasticity in speech perception. *Cognition, 64*, B9-B17.

Pallier, C., Dehaene, S., Poline, J.-B., LeBihan, D., Argenti, A.-M., Dupoux, E., & Mehler, J. (2003). Brain imaging of language plasticity in adopted adults: Can a second language replace the first? *Cerebral Cortex, 13*, 155–161.

Paradis, J. (2001). Do bilingual two-year-olds have separate phonological systems? *International Journal of Bilingualism, 5*, 19–38.

Piccinini, P., & Arvaniti, A. (2015). Voice onset time in Spanish–English spontaneous code-switching. *Journal of Phonetics, 52*, 121–137.

Pierce, L. J., Chen, J.-K., Delcenserie, A., Genesee, F., & Klein, D. (2015). Past experience shapes ongoing neural patterns for language. *Nature Communications, 6*, 1–11.

Piske, T., MacKay, I.R.A., & Flege, J.E. (2001). Factors affecting degree of foreign accent in an L2: A review. *Journal of Phonetics* 29, 191–215.

Polka, L., & Bohn, O.-S. (1996). Across-language comparison of vowel perception in English-learning and German-learning infants. *Journal of the Acoustical Society of America, 100,* 577–592.

Polka, L., & Bohn, O.-S. (2003). Asymmetries in vowel perception. *Speech Communication, 41*, 221–231.

Polka, L., & Bohn, O.-S. (2011). Natural Referent Vowel (NRV) framework: An emerging view of early phonetic development. *Journal of Phonetics, 39*, 467–478.

R Core Team (2016). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria. URL: https://www.R-project.org/.

Ramallo, F. (2007). Sociolinguistics of Spanish in Galicia. *International Journal of the Sociology of Language, 184*, 21–36.

Ramallo, F. (2017a). Linguistic diversity in Spain. In Ayres-Bennett, W. & Carruthers, J. (Eds.). *Manual of Romance sociolinguistics* (pp. 462-493). Berlin / Boston, De Gruyter.
Ramallo, F. (2017b). Minority languages in media communication. In Bedijs, K., & Maaß, C. (Eds.), *Manual of Romance language in the media* (pp. 453-470). Berlin/Boston, De Gruyter.
Real Academica Española (RAE) Banco de datos (CORDE) [online]. Corpus diacrónico del español. <http://www.rae.es> [08/12/2017]
Real Decreto 1981/1979, de 20 de julio, por el que se regula la incorporación de la Lengua Gallega al sistema educativo en Galicia. *Boletín Oficial del Estado*, 21 agosto 1979.
Regueira, X.L. (1996). Galician. *Journal of the International Phonetic Association*, 26(2), 119-122.
Regueira, X. L. (1999a). Estándar oral e variación social da lingua galega. In R. Álvarez & D. Vilavedra (Eds.), Cinguidos por unha arela común: homenaxe ó profesor Xesús Alonso Montero (pp. 855–875). Santiago de Compostela: Universidade.
Regueira, X. L. (dir.). Dicionario de pronuncia da lingua galega. Santiago de Compostela: Instituto da Lingua Galega. <http://ilg.usc.es/pronuncia> [08/12/2017]
Reinisch, E., Vosni, D.R., Mitterer, H., & Holt, L.L. (2014). Phonetic category recalibration: What are the categories? *Journal of Phonetics, 45*, 91–105.
Renwick, M. E. L., & Ladd, D. (2016). Phonetic distinctiveness vs. lexical contrastiveness in non-robust phonemic contrasts. *Laboratory Phonology: Journal of the Association for Laboratory Phonology*, 7, 1–29.
Renwick, M.E.L., & Nadeu, M. (2018). A survey of phonological mid vowel intuitions in central Catalan. *Language and Speech*, http://journals.sagepub.com/doi/10.1177/0023830917749275.
Sancier, M. L., & Fowler, C. A. (1997). Gestural drift in a bilingual speaker of Brazilian Portuguese and English. *Journal of Phonetics, 25*, 421–436.
Scovel, T. (1988). *A time to speak: A psycholinguistic inquiry into the critical period for human speech*. Cambridge, MA: Newbury House.
Simon, E. (2010). Child L2 development: a longitudinal case study on Voice Onset Times in word-initial stops. *Journal of Child Language, 37*, 159–173.
Simonet, M. (2011). Production of a Catalan-specific vowel contrast by early Spanish-Catalan bilinguals. *Phonetica, 68*, 88-110.
Simonet, M. (2014). Phonetic consequences of dynamic cross-linguistic interference in proficient bilinguals. *Journal of Phonetics, 43*, 26–37.
Sloos, M. (2013): The reversal of the Bären-Beeren merger in Austrian Standard German. *Mental Lexicon, 8*, 353–371.
Snodgrass, J.G. & Vanderwart, M. (1980). A standardized set of 260 pictures: Norms for name agreement, image agreement, familiarity, and visual complexity. *Journal of Experimental Psychology: Human Learning and Memory, 6*, 174-215.
Tomé Lourido, G. (2018). *The role of social factors in bilingual speech processing: The case of Galician New Speakers.* Unpublished PhD dissertation: University College London.
Tomé Lourido, G., & Evans, B.G. (2015). Switching language dominance for ideological reasons: A study of Galician new speakers' speech production and perception. *Proceedings of the 18th International Congress of Phonetic Sciences* (ICPhS). Glasgow: University of Glasgow.
Tomé Lourido, G., & Evans, B.G. (2018). The effects of language dominance switch in bilinguals: Galician new speakers' speech production and perception. *Bilingualism: Language and Cognition*, https://doi.org/10.1017/S1366728918000603.
Traunmüller, H. (1990). Analytical expressions for the tonotopic sensory scale. *Journal of the Acoustical Society of America, 88*, 97–100.
Turell, M. T. (2001). *Multilingualism in Spain: Sociolinguistic and psycholinguistic aspects of linguistic minority groups*. Bristol: Multilingual Matters.
Ventureyra, V., Pallier, C., & Yoo, H. (2004). The loss of first language phonetic perception in adopted Koreans. *Journal of Neurolinguistics, 17*, 79–91.
Vidal Figueroa, T. (1997). Estructuras fonéticas de tres dialectos de Vigo. *Verba, 24*, 313–332.

Werker, J. F., & Tees, R. C. (1984). Cross-language speech perception: Evidence for perceptual reorganization during the first year of life. *Infant Behaviour and Development, 7,* 49–63.
Yeni-Komshian, G.H., Flege, J.E., & Liu, S. (2000). Pronunciation proficiency in the first and second languages of Korean-English bilinguals. *Bilingualism: Language and Cognition, 3,* 131-149.

Table 1 ***Participant background; GAL= Galician; SPAN = Spanish; all ages in years.***

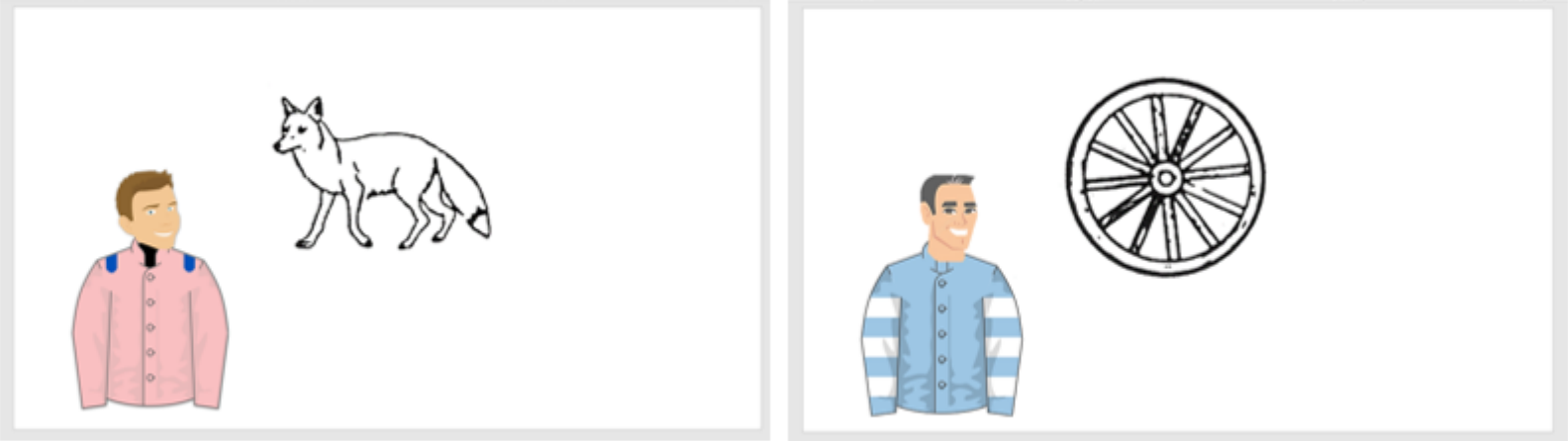
Group	Part. code	Gender	Age	Age/ context of learning GAL	Age/ context of learning SPAN	Age switch to GAL	Current use of GAL				
							% always	*% often*	*% at times*	*% seldom*	*% never*
SD	SD-1	F	40	8 years: school	birth: home	-	0	30	50	10	10
	SD-2	M	39	8 years: school	birth: home	-	22.2	11.1	33.3	22.2	11.1
	SD-3	F	39	5 years: school	birth: home	-	0	0	28.6	0	71.4
	SD-4	F	44	8 years: school	birth: home	-	10	10	40	10	30
	SD-5	M	40	8 years: school	birth: home	-	0	36.4	27.3	9.1	27.3
	SD-6	M	37	5 years: school	birth: home	-	0	0	0	0	100
	SD-7	F	38	14 years: school	birth: home	-	0	0	0	0	100
	SD-8	M	41	5 years: school	birth: home	-	0	17.6	5.9	29.4	47.1
	SD-9	M	43	8 years: school	birth: home	-	0	0	0	0	100
	SD-10	M	40	5 years: school	birth: home	-	0	22.2	33.3	11.1	33.3
GD	GD-1	F	40	birth: home[a]	4 years+: school	-	33.3	22.2	22.2	22.2	0
	GD-2	M	43	birth: home[a]	3-5 years: school	-	90.9	9.1	0	0	0
	GD-3	F	37	birth: home[a]	6 years+: school	-	88.9	0	11.1	0	0
	GD-4	M	38	birth: home[a]	5 years+: school	-	93.7	0	0	6.3	0
	GD-5	M	47	birth: home[a]	5 years+:school	-	100	0	0	0	0
	GD-6	F	40	birth: home[a]	3-5 years: school	-	81.25	0	12.5	6.25	0
	GD-7	F	28	birth: home[a]	3 years+: school	-	80	0	10	10	0
	GD-8	F	26	birth: home[a]	3 years+: school	-	100	0	0	0	0
DS	DS-1	F	39	birth>3: home[b]	birth>3: home	18	50	41.7	0	8.3	0
	DS-2	M	39	birth>3: home[b]	birth>3: home	24	43	57	0	0	0
	DS-3	M	40	birth>3: home[c]	birth>3: home	16	100	0	0	0	0
	DS-4	F	41	birth>3: home[b]	birth>3: home	27	90.9	0	0	0	9.1
	DS-5	F	38	birth>3: home[d]	birth>3: home	16	100	0	0	0	0
	DS-6	F	37	birth>3: home [c]	birth>3: home	23	53.8	15.4	30.8	0	0
	DS-7	F	39	birth: home[a]	4 years+: school	18	77.8	0	0	11.1	11.1
	DS-8	M	42	birth>3: home[d]	birth>3: home	30	55.6	11.1	22.2	0	11.1
	DS-9	F	41	birth>3: home[c]	birth>3: home	17	33.3	22.2	22.2	22.2	0
	DS-10	F	40	birth: home[a]	3 years+: school	16	64	36	0	0	0

[a] Galician-only home; [b] Both languages used in the home, but greater use of Spanish; [c] One parent- one language approach; no dominant home language reported
[d] Parents spoke to each other in Galician, but addressed child in Spanish.

Table 2 ***Target words***

FRONT VOWELS		
GAL /e/	**GAL /ɛ/**	**SPAN /e/**
cebra [ˈθeβɾa̪]“zebra”	*sete* [ˈsɛte̪] “seven”	*queso* [ˈkeso] “cheese”
cepo [ˈθepo̪] “trap”	*serpe* [ˈsɛɾpe̪] “snake”	*perro* [ˈpero] “dog”
neno [ˈneno̪] “child”	*tecla* [ˈtɛkla̪] “key”	*beso* [ˈbeso] “kiss”
testo [ˈesto̪] “flower pot”	*César* [ˈθɛsa̪ɾ] “Caesar”	*ceja* [ˈθexa] “eyebrow”
seto [ˈseto̪] “hedge”	*perna* [ˈpɛɾna̪] “leg”	*teja* [ˈtexa] “rooftile”

BACK VOWELS		
GAL /o /	**GAL /ɔ/**	**SPAN /o/**
goma [ˈgoma̪] “eraser”	*roda* [ˈrɔð̪a̪] “wheel”	*ropa* [ˈropa] “clothes”
mono [ˈmono̪] “monkey”	*porta* [ˈpɔɾta̪] “door”	*hombro* [ˈombɾo] “shoulder”
fonte [ˈfonte̪] “fountain”	*foca* [ˈfɔka̪] “seal”	*horno* [ˈoɾno] “oven”
lobo [ˈloβ̪o̪] “wolf”	*nove* [ˈnɔβ̪e̪] “nine”	*hoja* [ˈoxa] “leaf”
oso [ˈoso̪] “bear”	*óso* [ˈɔso̪] “bone”	*zorro* [ˈθoro] “fox”



Spanish token – target word: ‘zorro’ **Galician token – target word: ‘roda’**

Figure 1 ***Example of Spanish and Galician stimulus item***

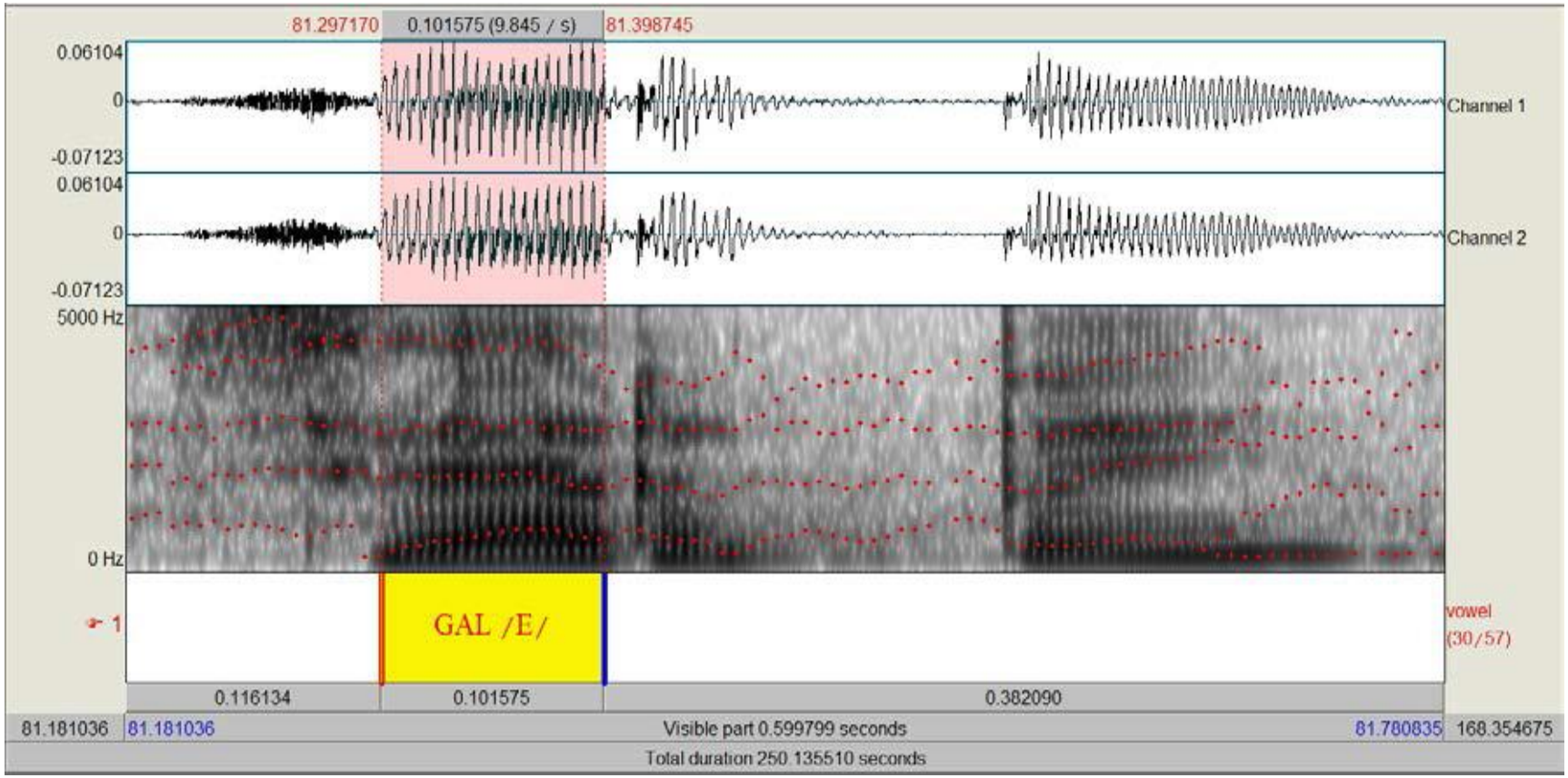
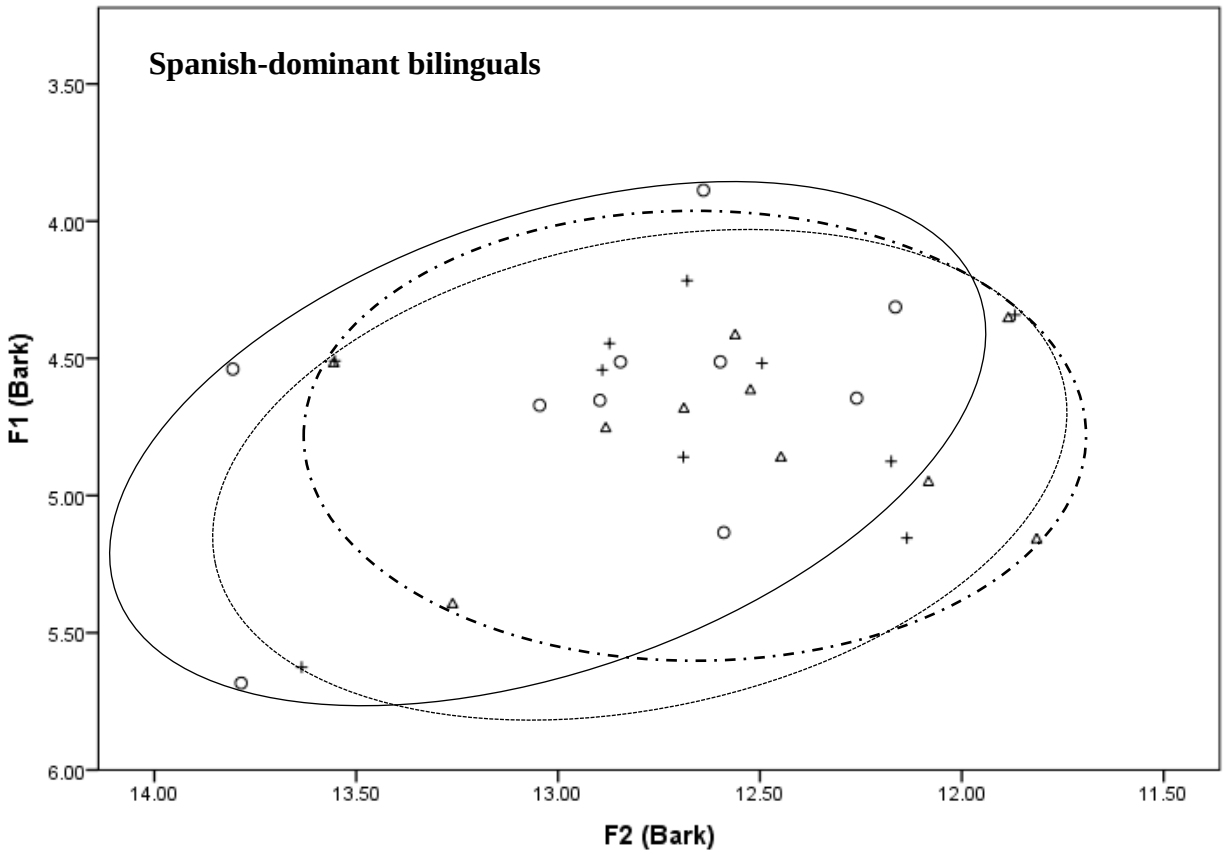
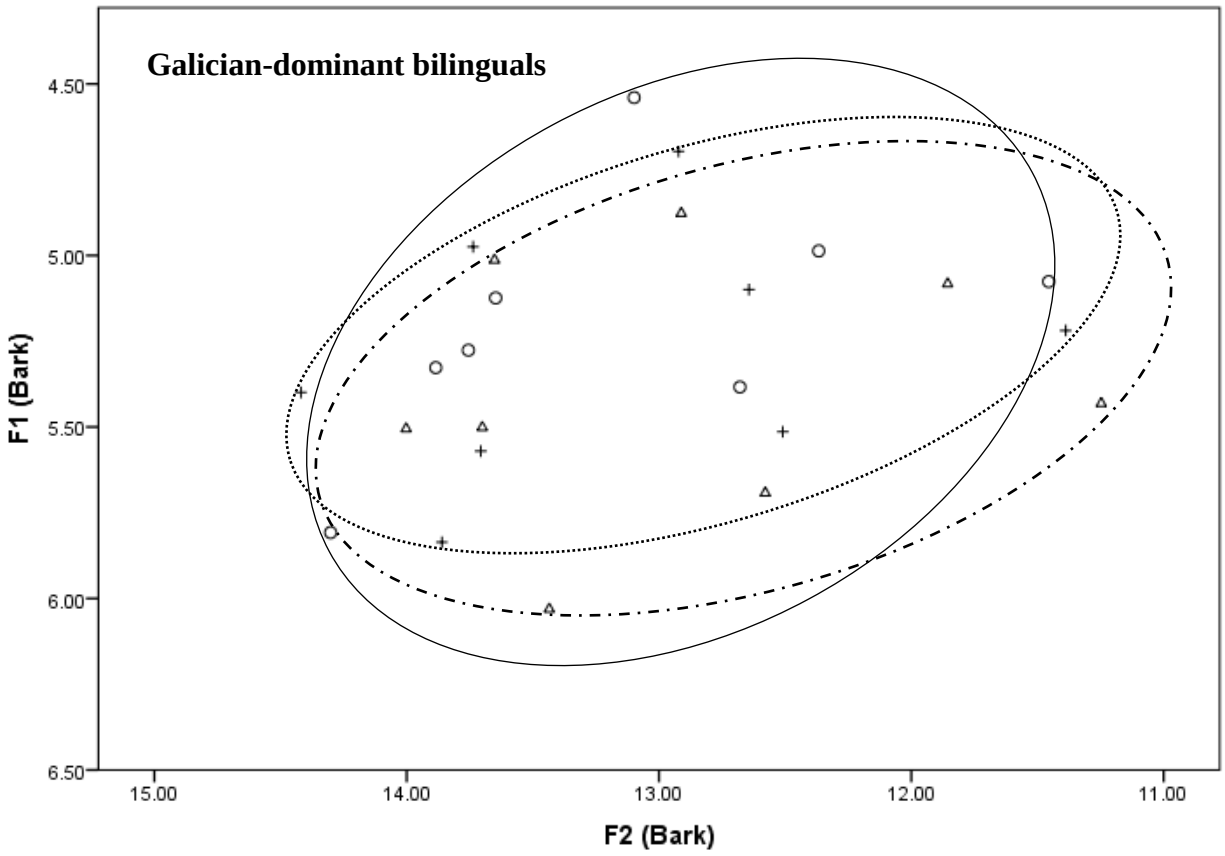


Figure 2 ***Segmentation of Galician /ɛ/ in 'serpe' (snake)***


Spanish-dominant bilinguals
3.50
4.00
4.50
5.00
5.50
6.00
F1 (Bark)
14.00
13.50
13.00
12.50
12.00
11.50
F2 (Bark)


Galician-dominant bilinguals
4.50
5.00
5.50
6.00
6.50
F1 (Bark)
15.00
14.00
13.00
12.00
11.00
F2 (Bark)

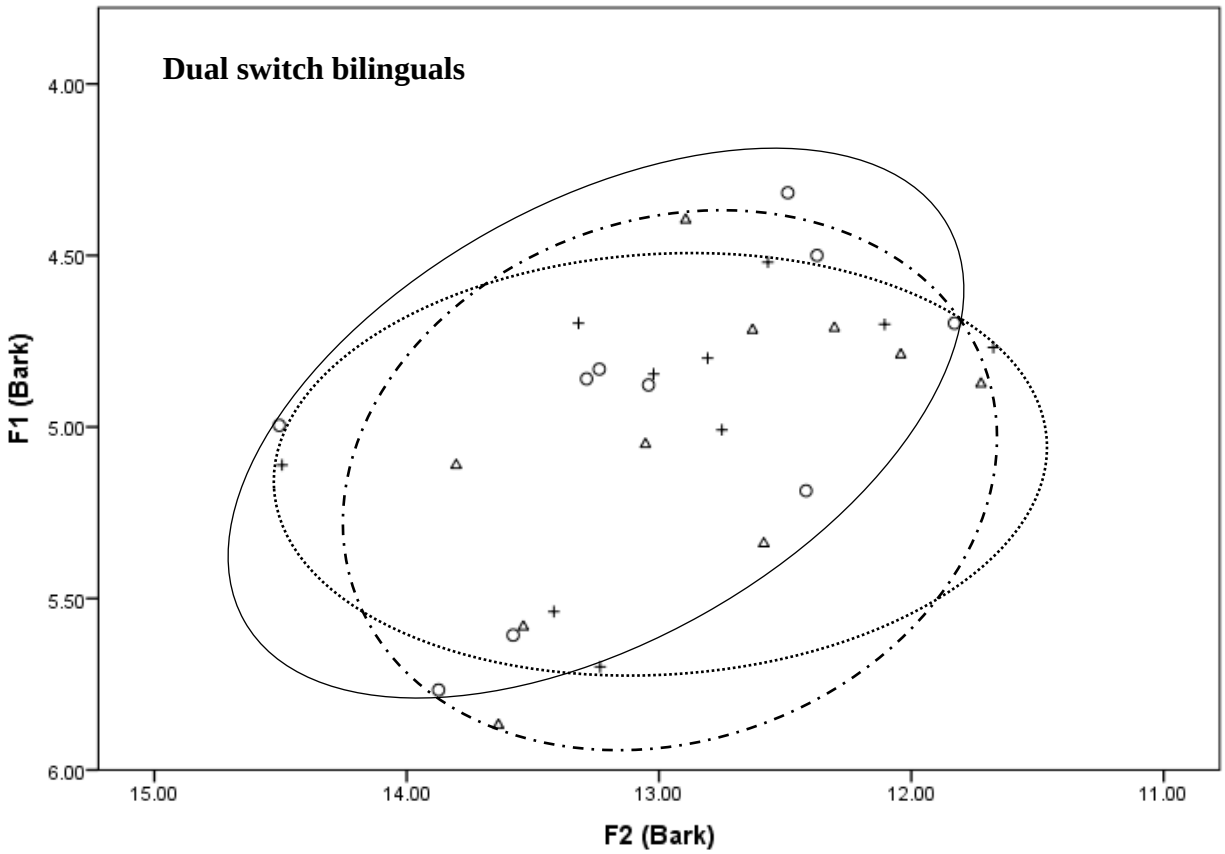


Figure 3 ***F1~F2 plot (Bark) for front vowels for SD bilinguals (top), GD bilinguals (middle) and DS bilinguals (bottom); Gal /e/ = o; Gal /ɛ/ = △; Span /e/ = +.***

Table 3 ***Results of mixed-effects model for front vowels***

F1 (Bark)	***β***	***SE***	***t***	***p***
Intercept	4.676	1.430	32.694	< 2e-16 ***
Group	2.742	9.631e	-2.847	0.00757 **
Vowel	7.687	6.139	0.125	0.90044
Condition	1.879	6.890	0.273	0.78518
Group*Vowel	1.426	3.065	0.047	0.96289
Group*Condition	1.803	5.569	0.324	0.74619
Vowel*Condition	3.546	5.253	0.675	0.49987
Group*Vowel*Condition	4.866	4.256	0.114	0.90900
F2 (Bark)				
Intercept	12.855422	0.224953	57.147	<2e-16 ***
Group	0.094652	0.170153	0.556	0.5822
Vowel	-0.116932	0.067701	-1.727	0.0874
Condition	-0.066584	0.070026	-0.951	0.3420
Group*Vowel	0.054328	0.034206	1.588	0.1163
Group*Condition	0.103855	0.056580	1.836	0.0668
Vowel*Condition	0.001218	0.053382	0.023	0.9818
Group*Vowel*Condition	-0.020369	0.043236	-0.471	0.6377

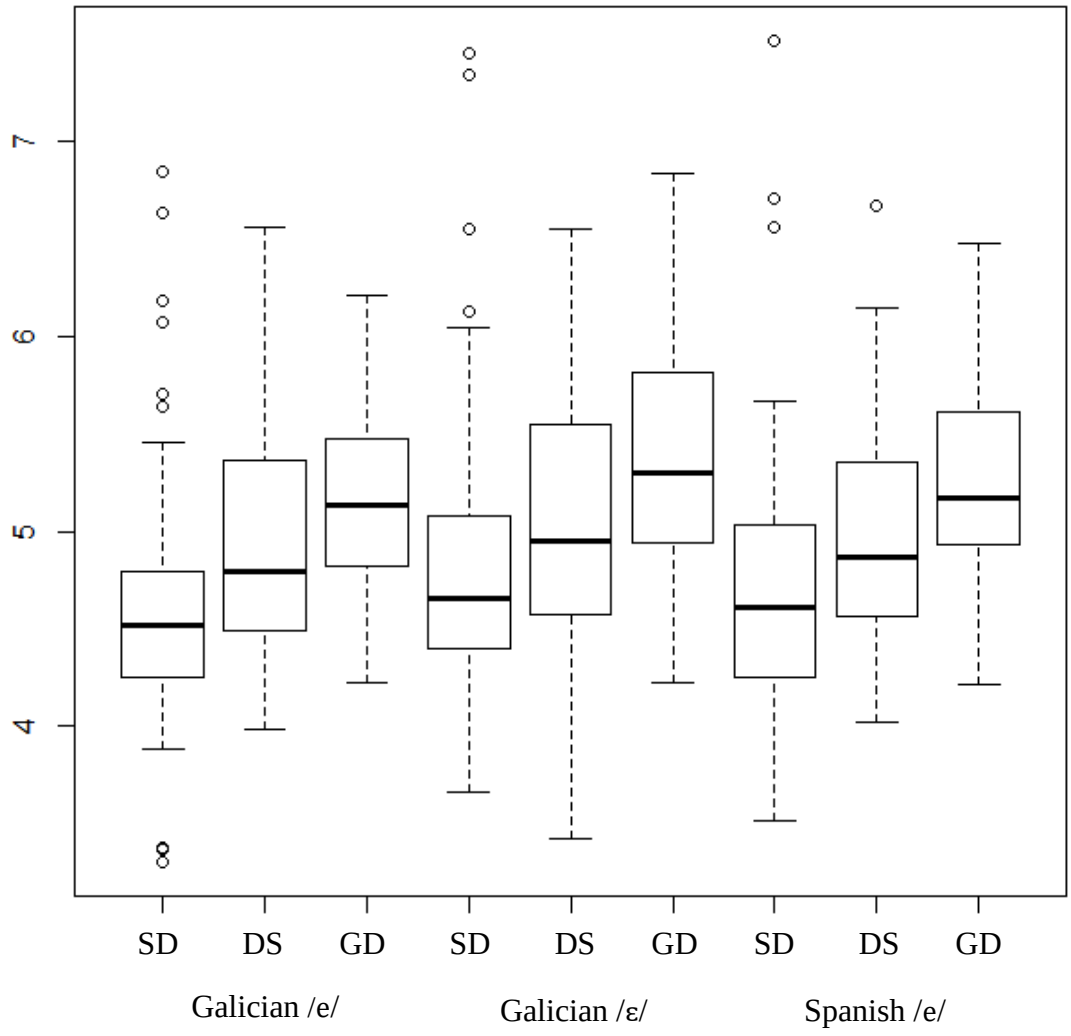
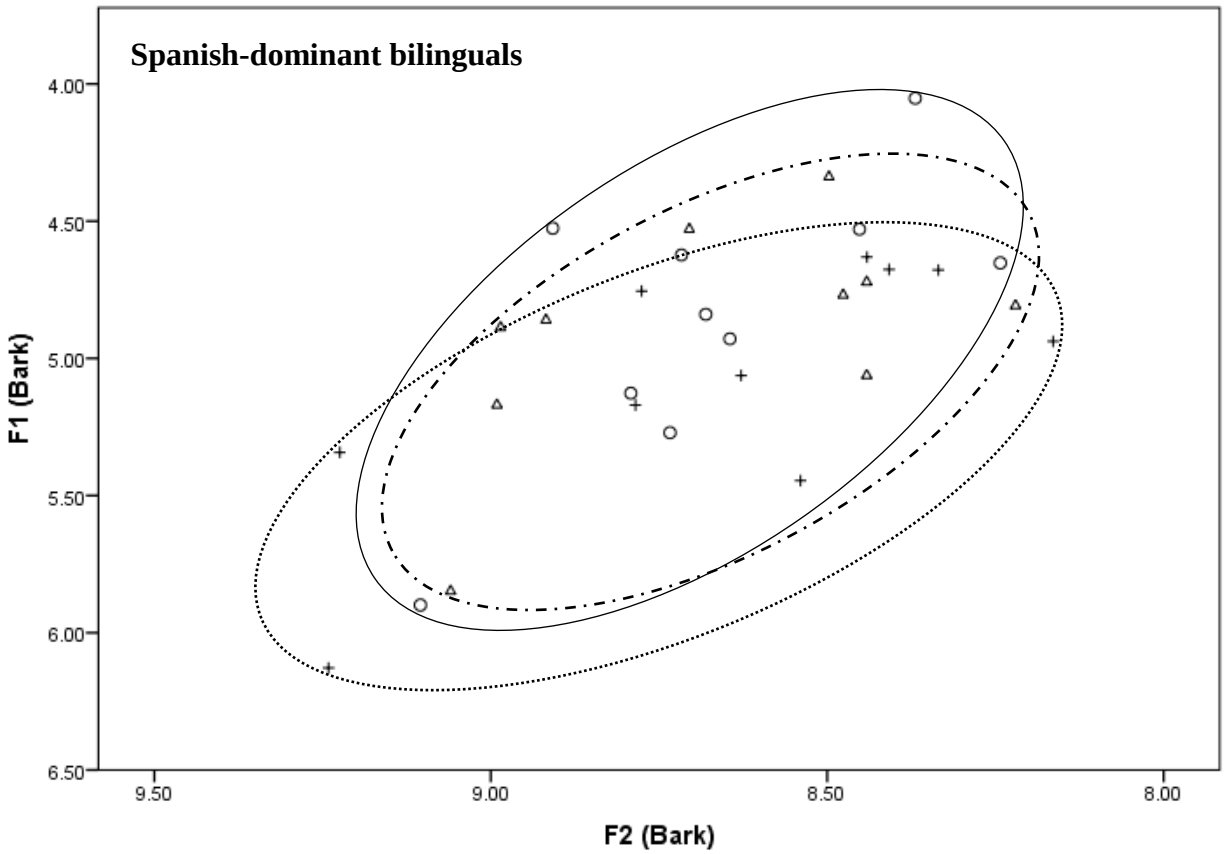
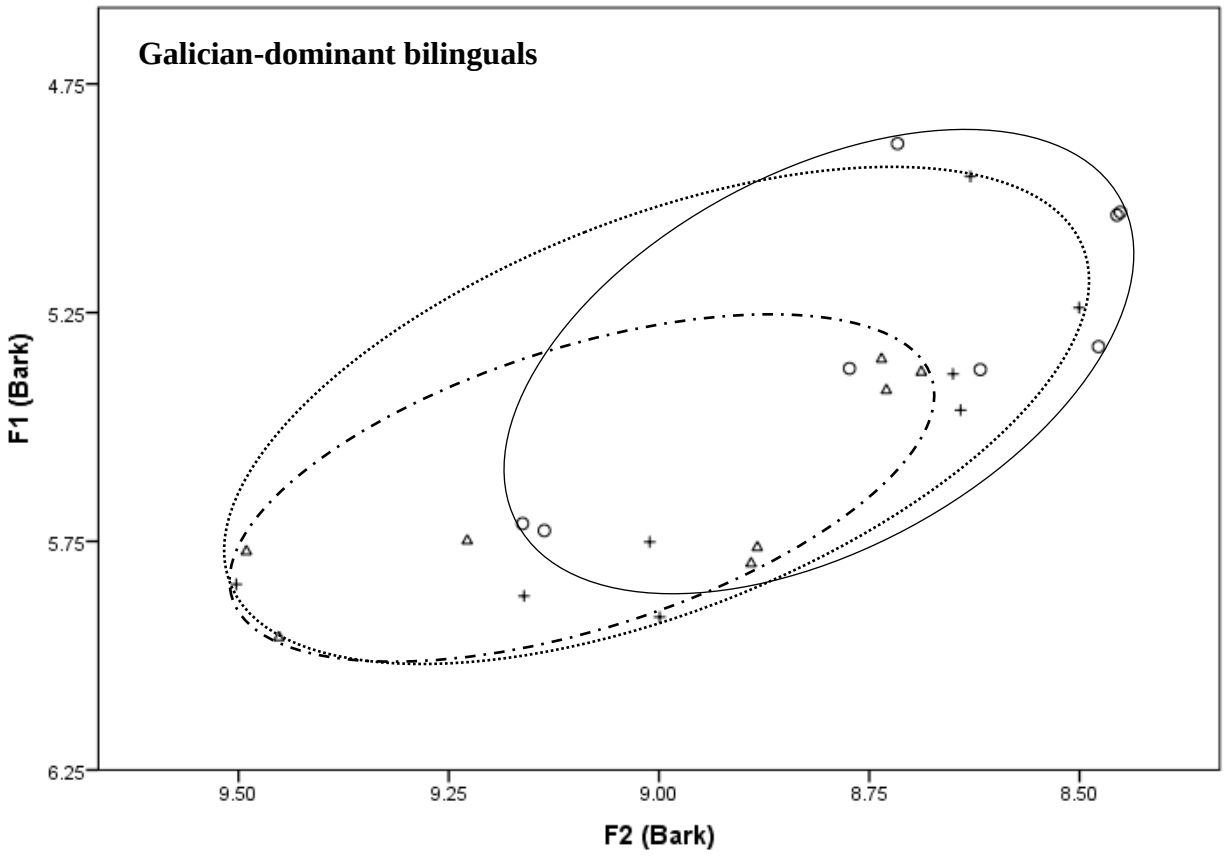


Figure 4 ***F1 (Bark) distribution of front vowels by group and vowel***


Spanish-dominant bilinguals
4.00
4.50
5.00
5.50
6.00
6.50
F1 (Bark)
9.50
9.00
8.50
8.00
F2 (Bark)


Galician-dominant bilinguals
4.75
5.25
5.75
6.25
F1 (Bark)
9.50
9.25
9.00
8.75
8.50
F2 (Bark)

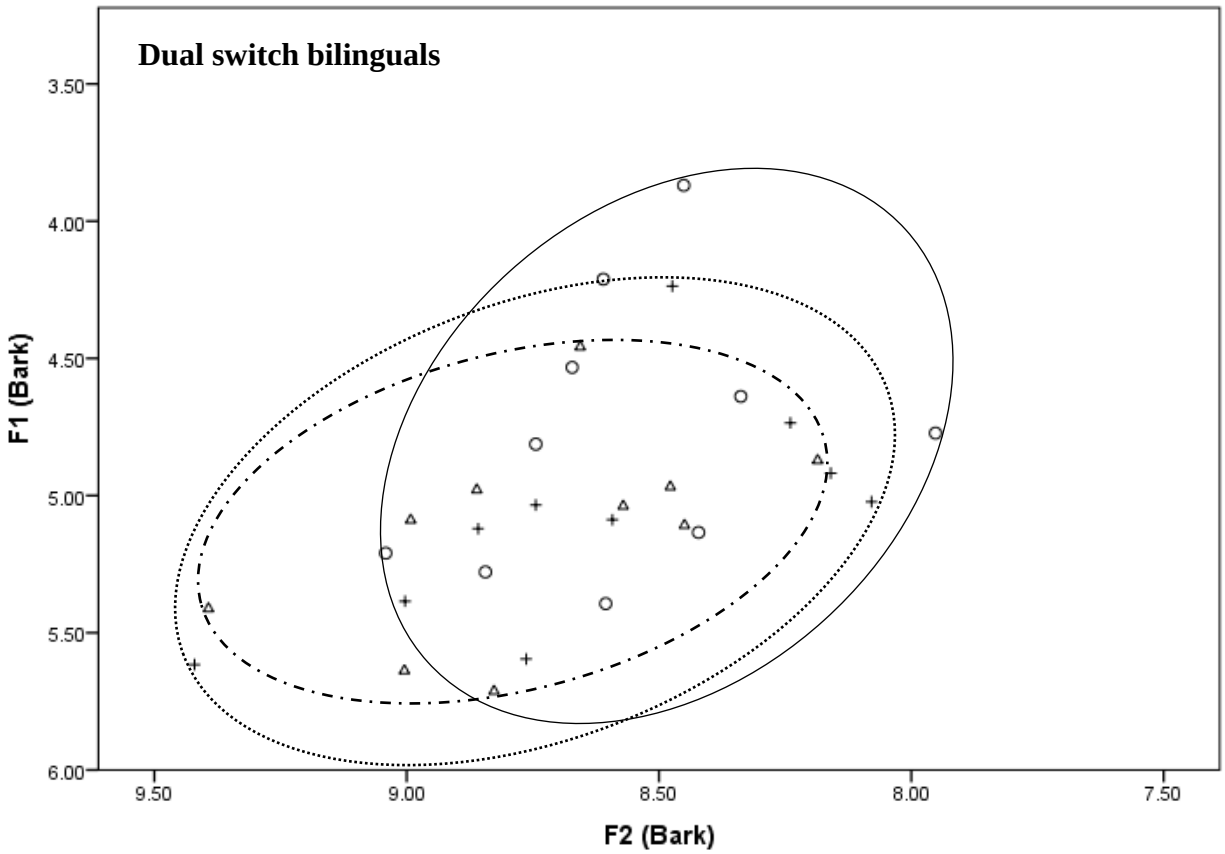


Figure 5 ***F1~F2 plot (Bark) for front vowels for SD bilinguals (top), GD bilinguals (middle) and DS bilinguals (bottom); Gal /ɑ/ = o; Gal /ɔ/ = ∆; Span /ɑ/ = +.***

Table 4 ***Results of mixed-effects model for back vowels***

F1 (Bark)	***β***	***SE***	***t***	***p***
Intercept	4.746908	0.142368	33.343	<2e-16 ***
Group	0.266784	0.102992	2.590	0.0139 *
Vowel	0.114674	0.071704	1.599	0.1150
Condition	0.034189	0.086071	0.397	0.6913
Group*Vowel	-0.006071	0.042871	-0.142	0.8878
Group*Condition	0.004172	0.069649	0.060	0.9522
Vowel*Condition	-0.018179	0.066612	-0.273	0.7850
Group*Vowel*Condition	0.025469	0.054544	0.467	0.6407
F2 (Bark)				
Intercept	8.616924	0.134413	64.108	<2e-16 ***
Group	0.098853	0.067498	1.465	0.151
Vowel	0.001491	0.071328	0.021	0.983
Condition	0.044249	0.068759	0.644	0.520
Group*Vowel	0.009297	0.032922	0.282	0.778
Group*Condition	-0.084083	0.055656	-1.511	0.131
Vowel*Condition	-0.026719	0.053229	-0.502	0.616
Group*Vowel*Condition	0.069093	0.043569	1.586	0.113

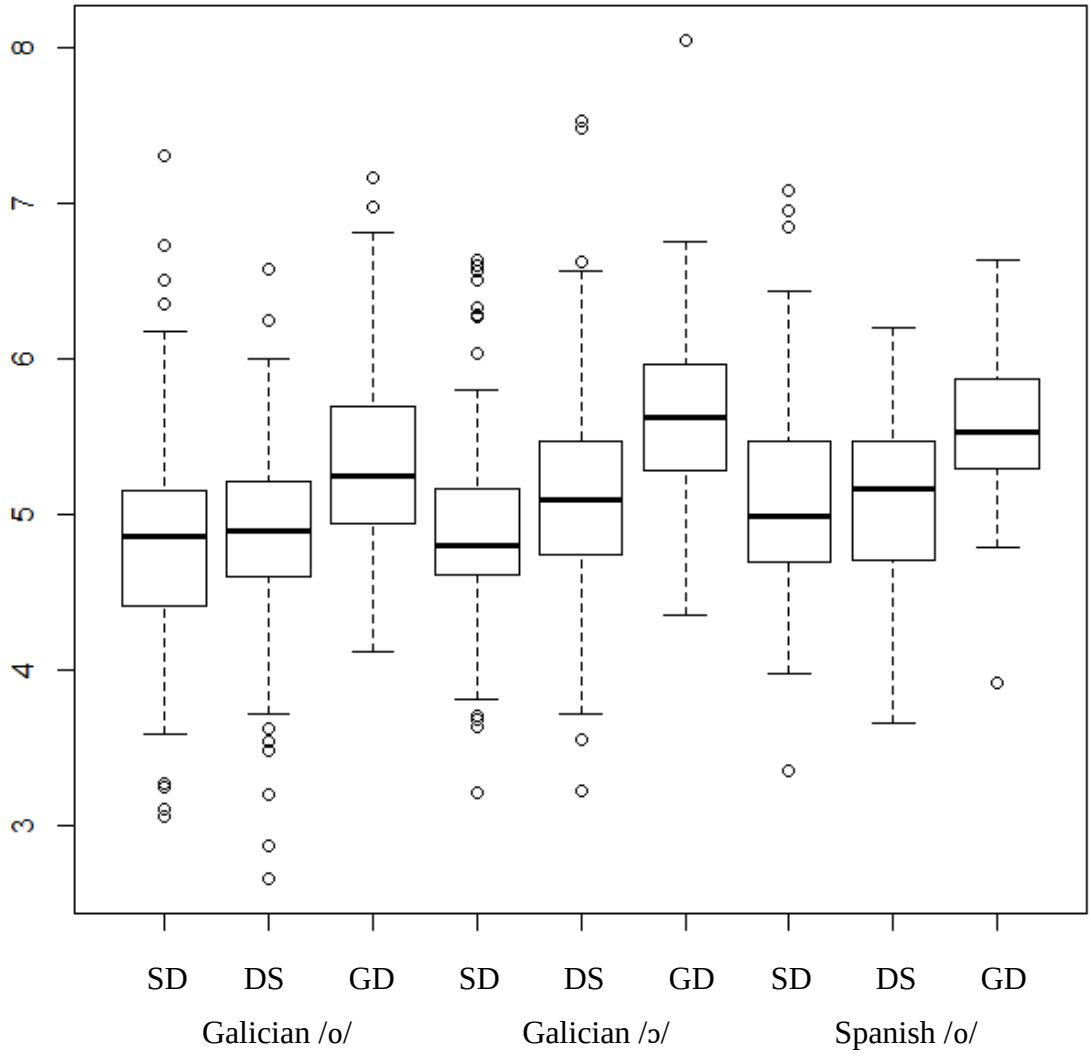


Figure 6 ***F1 (Bark) distribution of back vowels by group and vowel***

Table 5 ***Pillai scores for front vowel pairs; Pillai score with p > 0.05 = distinction, Pillai score with p < 0.05 = merger.***

Group	Part. code	Pillai score G /e/- G /ɛ/	p-value	merger/ split	Pillai score G /e/- S /e/	p-value	merger/ split	Pillai score G/ɛ/- S /e/	p-value	merger/ split
SD	SD-1	.034	.744	MERGED	.016	.869	MERGED	.049	.655	MERGED
	SD-2	.05	.646	MERGED	.032	.755	MERGED	.041	.70	MERGED
	SD-3	.053	.646	MERGED	.255	.147	MERGED	.19	.15	MERGED
	SD-4	.196	.14	MERGED	.18	.185	MERGED	.013	.888	MERGED
	SD-5	.211	.214	MERGED	.156	.305	MERGED	.003	.98	MERGED
	SD-6	.128	.358	MERGED	.176	.314	MERGED	.016	.867	MERGED
	SD-7	.142	.233	MERGED	.126	.317	MERGED	<.001	.998	MERGED
	SD-8	.084	.498	MERGED	.009	.937	MERGED	.112	.322	MERGED
	SD-9	.194	.16	MERGED	.241	.111	MERGED	.04	.694	MERGED
	SD-10	.343	.043	**DISTINCT**	.119	.386	MERGED	.276	.065	*MERGED
GD	GD-1	.150	.250	MERGED	.193	.161	MERGED	.058	.603	MERGED
	GD-2	.203	.145	MERGED	.314	.041	**DISTINCT**	.468	.005	**DISTINCT**
	GD-3	.294	.062	*MERGED	.491	.005	**DISTINCT**	.009	.925	MERGED
	GD-4	.084	.497	MERGED	.193	.162	MERGED	.179	.205	MERGED
	GD-5	.240	.097	*MERGED	.038	.720	MERGED	.188	.170	MERGED
	GD-6	.075	.515	MERGED	.339	.030	**DISTINCT**	.156	.236	MERGED
	GD-7	.467	.005	**DISTINCT**	.147	.328	MERGED	.128	.291	MERGED
	GD-8	.339	.068	*MERGED	.131	.463	MERGED	.149	.299	MERGED
DS	DS-1	.064	.628	MERGED	.159	.273	MERGED	.09	.472	MERGED
	DS-2	.244	.07	*MERGED	.374	.019	**DISTINCT**	.161	.189	MERGED
	DS-3	.17	.205	MERGED	.077	.506	MERGED	.059	.599	MERGED
	DS-4	.224	.218	MERGED	.076	.553	MERGED	.122	.403	MERGED
	DS-5	.05	.647	MERGED	.058	.604	MERGED	.044	.682	MERGED
	DS-6	.231	.107	MERGED	.032	.758	MERGED	.389	.015	**DISTINCT**
	DS-7	.07	.579	MERGED	.328	.051	***MERGED	.308	.044	**DISTINCT**
	DS-8	.155	.238	MERGED	.153	.243	MERGED	.01	.919	MERGED
	DS-9	.228	.126	MERGED	.067	.638	MERGED	.039	.729	MERGED
	DS-10	.014	.888	MERGED	.124	.324	MERGED	.129	.310	MERGED

*Approaches significance ($p < .01$)

Table 6 ***Pillai scores for back vowel pairs; Pillai score with p > 0.05 = distinction, Pillai score with p < 0.05 = merger.***

Group	Part. code	Pillai score G /o/- G /ɔ/	p-value	merger/ split	Pillai score G /o/- S /o/	p-value	merger/ split	Pillai score G/ɔ/- S /o/	p-value	merger/ split
SD	SD-1	.004	.965	MERGED	.126	.317	MERGED	.238	.099	*MERGED
	SD-2	.064	.569	MERGED	.197	.155	MERGED	.109	.377	MERGED
	SD-3	.003	.975	MERGED	.043	.703	MERGED	.056	.613	MERGED
	SD-4	.041	.699	MERGED	.005	.954	MERGED	.053	.628	MERGED
	SD-5	.17	.247	MERGED	.245	.161	MERGED	.055	.656	MERGED
	SD-6	.06	.589	MERGED	.115	.354	MERGED	.115	.355	MERGED
	SD-7	.134	.293	MERGED	.221	.12	MERGED	.082	.484	MERGED
	SD-8	.21	.135	MERGED	.015	.885	MERGED	.012	.909	MERGED
	SD-9	.067	.574	MERGED	.244	.107	MERGED	.184	.177	MERGED
	SD-10	.098	.417	MERGED	.026	.797	MERGED	.062	.581	MERGED
GD	GD-1	.118	.345	MERGED	.053	.627	MERGED	.028	.788	MERGED
	GD-2	.023	.821	MERGED	.023	.819	MERGED	.018	.814	MERGED
	GD-3	.119	.363	MERGED	.041	.731	MERGED	.055	.638	MERGED
	GD-4	.197	.155	MERGED	.176	.192	MERGED	.037	.726	MERGED
	GD-5	.750	<.001	**DISTINCT**	.163	.220	MERGED	.544	.001	**DISTINCT**
	GD-6	.067	.211	MERGED	.148	.245	MERGED	.005	.955	MERGED
	GD-7	.113	.362	MERGED	.017	.879	MERGED	.075	.557	MERGED
	GD-8	.446	.007	**DISTINCT**	.522	.002	**DISTINCT**	.055	.619	MERGED
DS	DS-1	.077	.506	MERGED	.07	.581	MERGED	.002	.985	MERGED
	DS-2	.233	.119	MERGED	.041	.748	MERGED	.231	.139	MERGED
	DS-3	.17	.247	MERGED	.347	.063	*MERGED	.303	.066	*MERGED
	DS-4	.286	.068	*MERGED	.238	.114	MERGED	.068	.547	MERGED
	DS-5	.265	.116	MERGED	.563	.002	**DISTINCT**	.084	.498	MERGED
	DS-6	.041	.714	MERGED	.014	.894	MERGED	.063	.575	MERGED
	DS-7	.067	.574	MERGED	.043	.687	MERGED	.08	.518	MERGED
	DS-8	.111	.368	MERGED	.202	.147	MERGED	.053	.628	MERGED
	DS-9	.078	.501	MERGED	.273	.067	*MERGED	.112	.364	MERGED
	DS-10	.100	.408	MERGED	.179	.187	MERGED	.023	.821	MERGED

*Approaches significance (p<.01)