Phonetic production in early and late German-Spanish bilinguals

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A mis padres, Ángeles Moreno y Félix Ruiz, y a mi abuela Maruja;

por su apoyo incondicional.

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"Beati Hispani quibus bibere vivere est."

"Lucky the Spaniards, for whom living is drinking."

Anonymous

"Wer fremde Sprachen nicht kennt, weiß nichts von seiner eigenen."

"Those who know nothing of foreign languages know nothing of their own."

Johann Wolfgang Von Goethe

Abstract

The aim of this study was the investigate both the acoustic differences and the global accent ratings of different types of bilinguals. The 40 speakers who participated in the study were divided into five groups (8 members per group). There were two groups of monolinguals (Spanish and German), one group of L1 Spanish – L2 German proficient late bilinguals, and two groups or early bilinguals (most of them also simultaneous bilinguals). For one group of the early bilinguals, Spanish was the societal language during childhood and German the heritage language, whereas the other group was brought up in Germany and acquired Spanish at home.

The study combines the use of global accent ratings, as typically done in bilingualism studies (e.g. Flege et al., 1995; or Oyama, 1976), with linguistic (acoustic) analyses, as proposed in Abrahamsson & Hyltenstam (2009). The acoustic studies focus on segmental phonetics, namely different aspects of vowels, stops, fricatives, and rhotics were investigated, which cover more than 75% of the segments of each language. Lastly, the study evaluated the impact of each of these phonetic features in the global accent ratings.

The findings support the idea that early exposure to a language does not guarantee a native-like pronunciation (Abrahamsson & Hyltenstam, 2009), as only half of the early bilinguals passed for natives in their heritage language despite presenting few phonetic deviations from monolingual norm. On the contrary, all of them passed for natives in their societal language. In turn, the late bilinguals were very far from monolinguals in the global accent ratings and, to a lesser extent, in the acoustic studies. The evaluation of the impact of each phonetic feature on global accent ratings seemingly suggests that other aspects (most likely intonation) can better account for global accent ratings when the speakers evaluated are highly proficient.

Keywords: early bilinguals, late bilinguals, simultaneous bilinguals, heritage-language speakers, Spanish, German, vowels, stops, fricatives, rhotics, and global accent.

Kurzfassung

Das Ziel dieser Studie bestand darin, sowohl die akustischen Unterschiede als auch die Globalakzentbewertungen bei verschiedenen Arten von bilingualen Sprechern zu untersuchen. 40 Sprecher haben an dieser Studie teilgenommen und wurden in fünf Gruppen aufgeteilt (8 Mitglieder pro Gruppe). Es gab zwei Monolingualgruppen (Spanisch und Deutsch), eine Gruppe von *late bilinguals* (L1 Spanisch - L2 Deutsch) und zwei Gruppen von *early bilinguals* (die meisten davon auch *simultaneous bilinguals*). Für eine Gruppe der *early bilinguals* war Spanisch während der Kindheit die Umgebungssprache und Deutsch die *heritage language*, während die andere Gruppe in Deutschland aufgewachsen ist und zu Hause Spanisch erworben hat.

Wie von Abrahamsson & Hyltenstam (2009) vorgeschlagen, kombiniert diese Studie die Verwendung der Globalakzentbewertungen, die typischerweise in Bilingualismusstudien durchgeführt werden (z. B. Flege et al., 1995; oder Oyama, 1976), mit sprachlichen (akustischen) Analysen. Die akustischen Studien konzentrieren sich auf die segmentale Phonetik, wobei verschiedene Aspekte von Vokalen, Verschlusslauten, Raubelauten und r-Lauten untersucht wurden, die mehr als 75% der Segmente jeder Sprache abdecken. Zuletzt wertet die Studie die Auswirkungen jedes dieser phonetischen Merkmale auf den Globalakzentbewertungen aus.

Die Ergebnisse unterstützen die Annahme, dass bei einer frühzeitigen Exposition gegenüber einer Sprache die Sprecher nicht unbedingt als Muttersprachler wahrgenommen werden (Abrahamsson & Hyltenstam, 2009), das war der Fall für die Globalakzentbewertungen in ihrer *heritage language* für die Hälfte der *early bilinguals* dieser Studie, obwohl nur wenige phonetische Abweichungen von der einsprachigen Norm vorlagen. Dagegen wurden alle in ihrer Umgebungssprache als Muttersprachler angesehen. Im Gegenzug gab es wichtige Unterschiede zwischen den *late bilinguals* und den Einsprachigen bei den Globalakzentbewertungen und bis zu einem gewissen Punkt auch in den akustischen Studien. Die Bewertung der Auswirkungen jedes phonetischen Merkmals auf der Bewertung der Globalakzente deutet anscheinend darauf hin, dass andere Aspekte (höchstwahrscheinlich Intonation) größere Auswirkungen auf Globalakzentbewertungen haben, wenn die bewerteten Probanden sehr kompetent sind.

Keywords: *early bilinguals*, *late bilinguals*, *simultaneous bilinguals*, *heritage-language speakers*, Spanisch, Deutsch, Vokale, Verschlusslaute, Reibelaute, r-Laute, und Globalakzent.

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1 Introduction

Bilinguals are neither the sum of two monolinguals' halves nor two monolinguals in one person (Grosjean, 1989). The most obvious difference between bilinguals and monolinguals is, of course, quantitative, as reflected in the prefixes that form these two words. However, being bilingual is also markedly different in nature to being monolingual, since the two languages are bound to interact with each other. This mutual influence is the norm rather than the exception (Flege, 2007: 365) and can take place in different ways (e.g. transfer or merge), in different directions (from stronger to weaker language and *vice versa*), and with different intensities. Because of that, bilinguals typically present some differences in relation to monolinguals in at least one of their two languages.

In addition, phonetics is the linguistic domain most prone to interaction between two languages, because variation is one of its intrinsic characteristics. To begin with, groups of speakers from the same area and social characteristics largely share the same grammar and lexicon (to a lesser extent this also applies to speakers who are socially and/or geographically distant), whereas each single person has their own distinctive pitch. Moreover, phonetics has a muscular basis, and minute differences in tongue, glottis, or lip position typically produce measurable acoustic differences. Thus, one speaker rarely produces identical tokens of the same sounds, but rather similar tokens within a given range.

Communication is therefore only possible because listeners are equipped with an abstraction capacity that allows them to ignore many of these individual differences in order to decodify the linguistic signal into meaningful pieces of information, which results in the ability to identify two sounds that are acoustically different, i.e. objectively different, as instances of the same phoneme (e.g. the same vowel produced by an adult male and a little girl). In this complex and fascinating process of filtering out the variation in the acoustic signal caused by anatomical differences in order to have the same abstract representation in the listener's mind, much metalinguistic information is retained. Listeners are usually able to recognise, at least vaguely, the social and geographical background of the speakers. Besides, even when the speaker uses an unfamiliar variety of their language, listeners are usually able to discriminate, given sufficient time, whether their interlocutor is a native speaker or not.

Since the rise of bilingualism studies, the question of whether bilinguals can pass by natives in one or both their languages has received much attention, which, of course, has no straightforward and single answer, since the category 'bilingual' is much more heterogeneous than that of 'monolingual'. For instance, the amount and type of input of bilinguals who live in Wales or Catalonia is very different to that of a German child whose parents speak at home Albanian. In migrant contexts, whether only one or both progenitors speak at home a language which is not the societal one will also impact the child's linguistic development. Even the number of siblings, the frequency of visits and contact with the extended family, or the possibility of finding other speakers of the language in the new country may affect the linguistic outcome of bilinguals. Besides, factors other than amount of input such as individual aptitude, and attitude are also relevant. However, the variable that has centred much of the discussion for decades is age of acquisition.

In his seminal work, Lenneberg (1967: 170-182) proposed the existence of a critical period in which language acquisition can be acquired without formal instruction. Many studies have since then attempted to determine whether there is a critical or sensitive period for language acquisition and, if so, at what age this opportunity window becomes closed. The most popular methodology has been the use of global accent ratings (e.g. Asher & García, 1969; Oyama, 1976; Flege, 1995; or Granena & Long, 2013). In turn, other studies have investigated specific aspects of bilingual phonetic production (e.g. stops or vowel production; Lein et al., 2016, and Amengual & Chamoro, 2015, respectively).

Precisely, the value of this research lies in that it brings together the methods and findings of both types of studies by analysing the same bilinguals with both global accent ratings and a series of acoustic studies that cover most of the phonetic inventories of the two languages here researched, i.e. Spanish and German. As will be seen in more detail in section 2, the selection of segments analysed covers more than 75% in both languages, which ensures that if there are differences at segmental level in the speech of bilinguals, they will be found.

This combined approach contributes to the theoretical understanding of bilingual phonetic systems, because it allows to understand how the two phonetic systems of a bilingual interact with each other (by means of the acoustic studies), which allows to answer the question of whether bilinguals *are* different; furthermore, it also investigates whether there are correlations between these phonetic differences and the way the speakers are *perceived* (by means of the global accent ratings). Thus, links are established between these two types of studies.

As will be reviewed in 2.2, the gap in the literature on bilingual phonetics that this research aims to fill had already been noted in Abrahamsson & Hyltenstam (2009). These authors state that the mere use of global accent does not suffice to conclude whether there are differences among bilinguals and monolinguals and advocate in favour of objective linguistic scrutinies. The pertinence of this statement can be easily corroborated by observing monolingual communities, in which much of the variation present goes unnoticed to their speakers. In turn, the sole use of acoustic studies cannot tell us which differences are perceived by native speakers and which are filtered out.

Apart from the notable advantages of combining global accent ratings and acoustic studies, this procedure poses some methodological difficulties that must be considered. Whereas acoustic studies typically have a relatively low number of participants because of the time-consuming task of carrying out acoustic measurements, studies with only global accent ratings must include large samples in order to gain statistical robustness because of the ample gamut of factors that affect bilingual linguistic acquisition. Identifying whether there are phonetic differences between bilinguals and monolinguals is the core research central question of this study, whereas investigating whether these potential differences cause bilinguals to be perceived as non-natives derives from the central question. Therefore, a relative balance between the requirements of global accent and acoustic studies was sought; instead of including bilinguals with many different profiles, it was aimed to include 24 bilinguals, divided into three groups of speakers that were much homogeneous in terms of age of acquisition and amount of input, and 16 monolinguals, 8 for each language, who served as control speakers. This number of speakers is feasible to carry out acoustic studies, whilst focusing on only some specific bilingual profiles allows to draw valid conclusions from the global accent ratings.

This procedure has, of course, the disadvantage that not all variables that potentially affect the linguistic outcome were included, as this would have drastically increased the number of participants to an incompatible extent with the detailed linguistic scrutinies proposed by Abrahamsson & Hyltenstam (2009). As noted, and as the title of this thesis suggests, the variable age of acquisition is the backbone in this research. Thus, speakers were separated depending on whether they were early or late bilinguals. Almost all early bilinguals recruited are also simultaneous bilinguals, i.e. they have in common that they have acquired both languages since birth. There are a few exceptions that represent cases of consecutive bilingualism, i.e. the acquisition of an L2 after the L1 has been (partially) acquired (see Baker for a discussion on the terminology, 2006: 4, 97); nonetheless, they resemble much to the simultaneous bilinguals, since they started to acquire their L2 during kindergarten.

In addition, the three groups are also quite homogeneous in terms of amount of input. All late bilinguals have intensive and regular contact with their L2 because of professional and/or personal reasons; in turn, the early bilinguals were further subdivided into German born early bilinguals, early bilinguals born in different Spanish-speaking countries, i.e. they were sorted out depending on their societal language during childhood, which is the most objective criterion to make a first distinction in terms of input for each language. Some of these early bilinguals differ, however, on heritage language use, both currently and during childhood, as will be noted in chapter 3. The combination of these profiles results into three basic profiles: 1) simultaneous or nearly simultaneous German born early bilinguals, 2) simultaneous or nearly simultaneous early bilinguals from Spanish-speaking countries, and 3) L1Spanish and L2German proficient late bilinguals.

Recruiting bilinguals that can clearly classify as either early or late bilinguals (irrespective of the definition used) overcomes the problem that the limits of early and late bilingualism are relatively fuzzy. Firstly, no clear frontier between these two types of bilingualism can be traced because each linguistic domain seems to be differently affected by the age of acquisition (Granena & Long, 2013). Secondly, it is important to bear in mind that other variables come at play in bilingual acquisition, which makes it impossible to establish a concrete age at which the opportunity window for native-like language acquisition is completely closed. Some of these variables are amount of input and/or use (Flege et al., 1997, and Yeni-Komshian et al., 2000), attitude (Moyer, 2014), and aptitude (Bylund et al., 2012, and De Keyser, 2000).

Despite the problems to establish a clear frontier between early and late bilingualism, there is strong accumulated evidence since Asher & García's study (1969) that confirms what the naïve person observes, i.e. children are more successful, on the long term, in language learning than adults (e.g. Oyama, 1976 or Granena & Long, 2013). Some researchers have noted, however, the impossibility of controlling the effect of this variable, as it confounds with other variables such as amount and type of input (Flege, 1987). Moreover, several researchers have claimed to have found exceptional speakers with a native-like command of pronunciation (Ioup et al., 1994; Molnár, 2010; Muñoz & Singleton, 2007; Nikolov, 2000; Moyer, 1999; Hopp & Schmid, 2013; or Bongaerts et al., 1995; 1997; and 2000), but others like Abrahamsson & Hyltenstam (2009) do not accept the type of evidence described in these authors because no linguistic scrutiny was carried out to check whether these speakers are actually indistinguishable from monolinguals. This line of thought is shared in this dissertation; in addition, further methodological aspects will be mentioned during the literature review to discard the existence of late bilinguals with native-like pronunciation.

A further valuable aspect of this research is that it integrates a holistic vision of bilingualism. Thus, the effect of age on societal and heritage language acquisition will be jointly discussed. Likewise, data on language attrition will also be considered as well as data on delayed L1 acquisition. Comparisons with the monolinguals are, of course, of much interest, but the interaction between the two languages is crucial to understand the essence of bilingualism given that bilingualism is tantamount to bidirectional linguistic influence.

It is also worth noting that the Spanish-German bilingualism in adults is largely under-researched from a phonetic perspective despite the considerable size of the Spanish-speaking community in Germany. Based on data provided by the German Federal Office of Statistics, it can be estimated that around 271.000 Spanish-speaking people (178.000 of which are Spaniards) lived in the country in 2017[1].

The combination of these two languages adds value to the research because it has been theorised that similar sounds are more difficult to acquire than totally new ones (Flege, 2007: 367), and the phonetic of these two languages allows to study both types of sounds. For instance, rhotics are completely

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1 https://www.destatis.de/DE/Publikationen/Thematisch/Bevoelkerung/MigrationIntegration/AuslaendBevoelkerung2010200177004.pdf?__blob=publicationFile

different in each language, differing in both place and manner of articulation, whereas, e.g. both German /ɛ/ nor /eː/ present some similarities with Spanish /e/, but none is identical.

Finally, this research contributes to the study of the Spanish and German varieties spoken by the two monolingual controls groups, since in order to identify and quantify the variation in the sample that was caused by the variable bilingualism, it was first necessary to describe what was typical in the respective monolingual communities. In so doing, new data and thorough reviews of the existing data have been provided for both languages.

This dissertation is structured as follows. Chapter two offers the theoretical background wherein this research is framed and reviews the literature of all relevant areas for this research. This review is divided into two major blocks: 2.1) the phonetic systems of Spanish and German and 2.2) bilingual phonetics, which covers the literature on global accent ratings, topics such as L2 learnability and language attrition, and acoustic studies with bilinguals. In chapter three, the methodology and results will be presented and discussed. Finally, chapter four closes this work with a conclusion.

2 Theoretical background

This section is divided into two major blocks: 2.1 (The sound systems of Spanish and German) and 2.2 Bilingual phonetics. 2.1 will provide the reader with the necessary understanding of the current state of research on the acoustic properties of the segments here investigated, whereas in 2.2 several interrelated topics within the field of bilingual phonetics are treated, namely L2 learnability in both early and late bilinguals (2.2.1), language attrition (2.2.2), and acoustic studies investigating specific aspects in the speech of bilingual individuals (2.2.3). Each of the two major blocks will count with its own separate subsection for concluding remarks (2.1.5 & 2.2.4, respectively).

2.1 The sound systems of Spanish and German

This block is structured following the phonetic segments that will be investigated for this dissertation, i.e. 2.2.1 is dedicated to vowels, 2.2.2 to stops, 2.2.3. to fricatives, and 2.2.4 to rhotics; lastly, in 2.2.5 a concise summary is provided in addition to some short notes on speech rhythm, intonation, and the rest of segments.

2.1.1 Vowels

The German vowel inventory is much richer than the Spanish one. Its vowels amount to 23 (including those without phoneme status), to which three more nasal vowels could be added, thus, summing up a total of 26 vowel sounds (excluding diphthongs). The 3 nasal vowels have been left aside because they are only present in foreign words, usually loanwords from French: *Abonnem**ent*** [ɑ̃] ‘subscription’,

Terrain [ɛ̃] 'terrain', or ***Fasson*** [ɔ̃] 'style'[2]. On the contrary, most recent work based on acoustic data do not recognise any allophone for Spanish (this will be treated in more detail later in this section), at least with a consistent distribution, which leaves the total count of vowel sounds in 5.

With five vowels and compared to that of German, the Spanish vocalic inventory may seem rather modest. However, such a small number of vowel phonemes is the most common cross-linguistically (Disner, 1984). On the other side, the German vowel repertoire is undoubtedly a very complex one.

2.1.1.1 Describing vowels

Vowels have been traditionally described using three parameters: height, backness, and roundedness (also called labialisation). This terminology is supposed to reflect tongue and lip position (height and backness on the one hand, roundedness on the other), which, as will be seen, is not completely accurate.

Traditional vowel charts represent vowel height on the Y-axis. The higher the vowel appears on the chart, the higher the tongue position is and vice-versa. It is also worth mentioning that a lower position of the tongue necessarily conveys a larger degree of aperture in the vocal tract, hence the also frequent use of the term aperture instead of height. The terms high or close and low or open can be thus used interchangeably with vowels.

Backness is represented on the X-axis; a back position on the chart represents that the sound is produced at the back of the vocal tract; conversely, when the tongue moves frontwards in order to produce a vowel, such a vowel is represented on the front part of the chart.

A third articulatory aspect is reflected on traditional vowel charts: roundedness, which is also called labialisation and refers to the state of the lips. These can be either spread or rounded, which can serve, like in German, to establish minimal pairs solely based on this feature. As can be seen on the IPA chart (figure 1), some vowels appear in pairs, like for example [i] and [y]; in those cases, the one to our left is always unrounded, and the one to our right always rounded.

Those three parameters refer to articulatory features, describing either the tongue or lips position. However, there is one more feature, acoustic in nature, which is relevant to describe the German vowel inventory: length. Strictly speaking, length simply refers to the duration of the vowel. This feature is claimed to suffice to contrast two vowels with the same quality, e.g. in Estonian (Asu & Teras, 2009). The case of German is more complicated, since the pairs that contrast in length do it also in vowel quality, except, possibly, [aː] and [a]. For this pair, length is clearly the distinctive feature, since not all speakers present also changes in vowel quality (C. Hall: [2]2003: 86).

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[2] These nasal vowels are sometimes replaced by non-nasal sequences of vowel + nasal, e.g. *Balkon* [balkoːn] or [balkɔŋ].

Typical vowel charts exclude vowel length, since it is signalled with the diacritic ":" next to the vowel, e.g. [e:]. This is the case of figure 1, which has been adapted from the IPA vowel chart to signal both Spanish and German vowels with phonemic status.

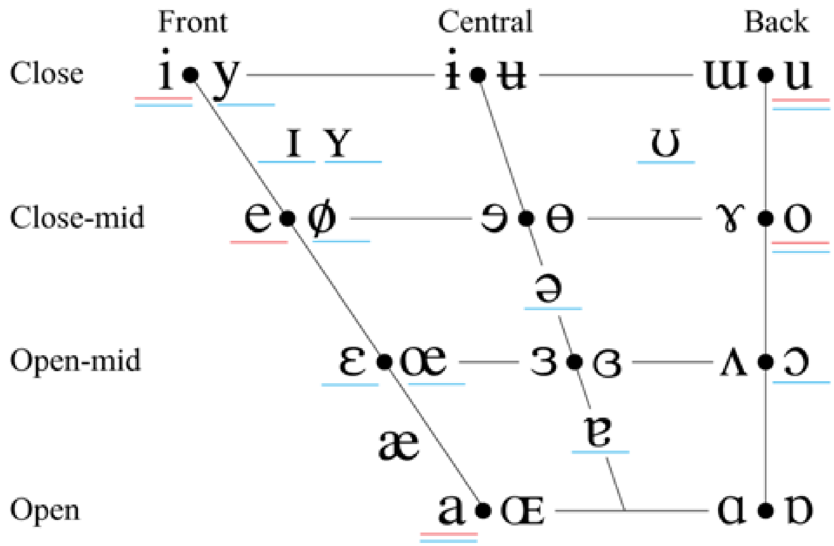

Figure 1: 2018 IPA vowel chart modified to mark vowels with phonetic status or consistent allophonic distribution; Spanish vowels are underlined in red, German ones in blue.

Table 1 provides examples of each existing sound for both Spanish and German.

Vowel	Spanish	German	Vowel	Spanish	German
[i]	*timo* 'swindle'	*vital* (*[ɪ]) 'vital'	[i:]	----	*spielen* 'to play'
[y]	----	*Zynismus* (*[ʏ]) 'cynicism'	[y:]	----	*lügen* 'to lie'
[ɪ]	----	*Zimmer* 'room'	[ʏ]	----	*Küsse* 'kisses'
[e]	*pelota* 'ball'	*Mechanik* (*[ɛ]) 'mechanics'	[e:]	----	*Mehl* 'flour'
[ø]	----	*Ökologie* (*[œ]) 'ecology'	[ø:]	----:	*Höhle* 'cave'
[ɛ]	----	*Bett* 'bed'	[ɛ:]	----	***Käse* 'cheese'
[œ]	----	*können* 'can'	[a]	*botella* 'bottle'	*Bann* 'spell'
[a:]/[ɑ:] ***	----	*Kahn* 'boat'	[ə]	----	*bereit* 'ready'
[ɐ]	----	*verzagen* 'to despair'	[u]	*tuyo* 'yours'	*Universität* (*[ʊ]) 'university'
[u:]	----	*Schule* 'school'	[ʊ]	----	*Zunge* 'tongue'
[o]	*oler* 'to smell'	*Olive* (*[ɔ]) 'olive'	[o:]	----	*Mode* 'fashion'
[ɔ]	----	*Sonne* 'sun'			

Table 1: Spanish and German monophtongs with and without phoneme status.
***** As noted in (Russ, 2010: 93), many speakers use the sounds in brackets instead.
****** [e:] typically appears instead of [ɛ:] in northern Germany.
*** [ɑ:] appears only in southern Germany.

As stated above, the traditional vowel charts are not entirely satisfactory in light of the newest articulatory and acoustic research. Esling's (2005) chart reflects the fact that for retracted vowels there is a movement of the root of the tongue towards the pharynx. As can be seen in figure 2, only the description of the German vowel inventory would be altered, namely, [ɔ], [ɐ], and [ɑː] (many authors claim that its pronunciation is actually [aː], as will be later discussed).

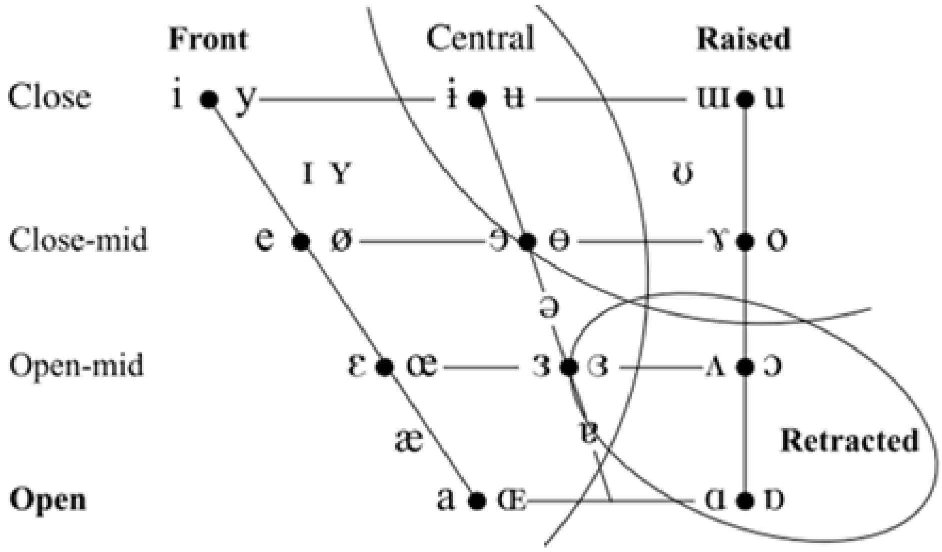

Figure 2: revised vowel chart, taken from Esling, 2005: 19.

Each of these articulatory descriptions has their own acoustic correlates. The first formant correlates negatively with tongue movement, i.e. the higher the position of the tongue, the lower the F1 (Martínez Celdrán, [2]2003: 78). Similarly, back vowels have a lower F2, whereas front vowels have higher F2 values. A more complex view is offered in Ladefoged ([7]2015: 197). According to him, the second formant is also affected by lip rounding, and he argues that the "degree of backness is best related to the difference between the first and the second formant frequencies. The closer they are together, the more 'back' a vowel sounds". As for the third formant, Ladefoged ([2]2005: 46) states that its frequency is heavily affected by the position of the lips. However, as he also describes in the same work ([2]2005: 161), lip rounding not only lowers the third formant, but also the first and second.

Finally, the acoustic correlate of vowel length is duration; however, there is an important difference between segmental duration and vocalic quantity. Segmental duration relies heavily on external factors such as the position within the intonation phrase, speech rhythm, speaking rate, syllable structure (vowels in open syllables tend to be longer than those in closed ones), and stress (stressed syllables usually present longer vowels than unstressed ones). On the contrary, vowel length is an intrinsic feature, i.e. all things being equal, [iː] is intrinsically longer than [i], [eː] than [e], and so on. Thus, a phonologically long vowel can be shorter than a phonologically short vowel if the short vowel appears in an intonation position, and in a syllabic context favouring longer segment durations.

Vowel feature	Acoustic correlates
Backness	Back vowels: smaller difference between F1 & F2 Front vowels: greater difference between F1 & F2
Height	High vowels: low first formant Low vowels: high first formant
Lip rounding	Formants are lowered in rounded vowels
Length	Much affected by intonation position and syllable structure, but also phoneme dependent

Table 2: acoustic correlates of vowel features.

2.1.1.2 Spanish vowels

In this subsection, an acoustic description of the Spanish vowels will be provided after a discussion about the total number of vowels that form the Spanish inventory. Firstly, the formant structure of each vowel will be presented; secondly, their duration will be reviewed; and, thirdly, their intensity.

2.1.1.2.1 Vowels with phoneme and/or allophonic status

The Spanish vowel system is often described as a triangle, with two high vowels /i u/, two mid vowels /e o/, and one low vowel /a/. Stressed vowels are generally longer than their unstressed counterparts in any language providing all other conditions are equal (e.g. syllable structure, speech rate or position within the intonational phrase), Nonetheless, such increase in vowel length in Spanish is never phonemic. Moreover, stressed vowels never equal in length German or English long vowels. They are simply longer in relation to their unstressed counterparts in Spanish. Additionally, it is of great importance to highlight that Spanish vowels are clearly articulated and do not converge in a schwa-type central sound in most dialects.

Two important exceptions to that general pattern are Mexican Spanish with its characteristic vowel weakening and elision (Lope Blanch, 1963) and Argentinean Spanish, in which lengthening in stressed and pre-boundary syllables is particularly prominent (Gabriel & Kireva, 2014).

In his seminal work, *Manual de pronunciación española*, first published in 1918, Navarro Tomás suggested that there is allophonic variation for the degree of aperture and backness of Spanish vowels. Supposedly, all vowels would see their quality altered before [x] or in contact with /r/ (for the exact details see Navarro Tomás, ([25]1991: 46-62), being more open than in any other context for [e i o u], and more velar for [a]. In any case, as he himself indicated, it would never be possible to speak of open vowels comparable to those of German. More recent research, carried out with more sophisticated techniques, has generally not ratified this claim (Monroy-Casas, [2]2004: 71-76), Quilis ([2]1999: 145), and Martínez Celdrán (1984: 288-301). In a later work, Martínez Celdrán & Fernández Planas ([2]2013: 183-188) analyse this question from both an acoustic and articulatory perspective. They analysed the formal but spontaneous speech of a TV-presenter and separated the contexts in which Navarro Tomás claimed vowels to be more open, and their data do not support Navarro Tomás' view. In addition to that speaker, they repeated the analysis with an informant uttering words embedded in a sentence. Again, they concluded that there were neither remarkable nor consistent acoustic differences. They did find, however, significant differences in their articulatory study for both /i/ and /e/ (back vowels were not investigated, but the authors presume that the results would have been similar). In view of their data, they concluded that this is an example of lack of linear relation between articulatory and acoustic parameters.

On the contrary, Hualde (2005: 121-122) defends, without mentioning empirical data, that in contact with palatal sounds, vowels *tend* to be higher, as in *p**e**cho* ‘chest’, and lower in contact with a trill and before /x/, as in *p**e**rro* ‘dog’ or *l**e**jos* ‘far’. Furthermore, he coincides with Navarro Tomás in noting that these vowels would never be as open as those of languages with open vowels with phoneme status, e.g. German, English, Catalan or Portuguese. However, as will be seen in the summary of this section, the literature review of formant values for both German and Spanish here presented seriously questions that view.

2.1.1.2.2 Formant structure

Before presenting the formant structure of Spanish vowels, it is convenient to highlight that absolute values are only a point of departure for comparison, since there are several elements which complicate the comparison between subjects and studies.

Firstly, speakers have different sizes for their vowel tract and, therefore, different resonances (which is the reason why most authors also offer separate values from men and women). These individual differences may fade away to a great extent when using large samples, but ideally all data should be normalised. Reviewing all normalisation methods is out of the scope of this research, but in the methodology section a justification of the method chosen will be provided.

Additionally, formant structure depends heavily on other factors such as speaking rate, position within the intonational phase, type of intonational phrase, and on the segments preceding and following the vowel. Unfortunately, the phonetic contexts in each of the reviewed studies are rarely identical. Despite all remarks and cautions expressed, an inter-study comparison of vowel formants in Spanish different dialects is provided in table 3.

According to Hualde (2005: 128), vowel qualities are remarkably stable among Spanish dialects. The present literature review seems to support this view except for Venezuelan Spanish, whose values differ to a great extent for some vowels.

Females	[i]		[e]		[a]		[o]		[u]		Prt
Study	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	
2011/Sp	400	2560	531	2159	801	1691	568	1155	431	921	10
2006/Sp	378	2553	538	2141	ND	ND	ND	ND	ND	ND	10
1990/Sp	256	1981	342	1596	580	1321	442	1217	300	600	8
1995/Sp	369	2685	576	2367	886	1712	398	1201	390	937	5
2015/Chil	321	2684	486	2557	697	1597	565	1608	420	1540	78
2009/Cub	ND	ND	694	2254	ND	ND	667	1444	ND	ND	1
2001/Mex	322	2731	520	2407	910	1755	525	1178	394	818	2
2014/Mex	420	2275	516	2058	736	1719	527	1261	387	1114	4
2011/Per	400	2669	525	2223	762	1610	580	1121	430	954	9
2000/Ven	262	2778	733	2554	1020	1691	881	2074	414	1617	25
Mean/all studies	348	2546	546	2232	799	1637	573	1362	396	1063	152
Range/all studies	256-420	1981-2778	342-733	1596-2557	580-1020	1321-1755	398-881	1121-2074	300-431	600-1617	152

Table 3: vowel formants in the Spanish-speaking world (female speakers).

Legend of tables 3: Prt: number of participants / Sp = Spain / Chil = Chile / Cub = Cuba / Mex = Mexico / Per = Peru / PR = Puerto Rico / Ven = Venezuela / ND = no data. Based on data reported in: Albalá et al. (2008), Almeida (1990), Bradlov (1995), Cervera & et al. (2001), Chládková et al. (2011), Díaz et al. (2015), Frazzetto (2000), Madrid Servín & Marín Rodríguez (2001), Madrid Servín & Santana Cepero (2009), Martín-Butragueño (2014), Martínez Celdrán (1995), and Morrison (2006: 43).

Table 3 covers quite extensively most of the dialectal diversity in both Spain (most studies cover northern and central Spanish, but other varieties, like Canarian, are also represented; Almeida, 1990) and the rest of the Spanish-speaking world. There are, however, two notable exceptions: Argentinean and Andalusian vowels. The latter poses no problem since no participant from this region participated in the present investigation. For the former, Guirao & Borzone de Manrique (1975) offer a vowel chart with approximate values.

It is also important to highlight the general overall high correspondence between the data presented in Martínez Celdrán (1995) and the means reported in table 3. Martínez Celdrán's dispersion limits are larger, which is explained by the fact that my calculus is more conservative than that of Martínez Celdrán, as it only includes reported means, instead of the whole range observed in every speaker of each study.

As previously signalled, there are different factors affecting formant structure. Nadeu (2014) found that stress had a significant effect on both F1 and F2. She also expresses that in her data there is large intra- and interspeaker variation in the way that stress affects vowel quality. At least in some speakers, the tendency is, to a larger or lesser extent, for centralisation in unstressed vowels. But even when that happens, it would never be phonologised, as she herself mentions.

In a similar vein, Martínez Celdrán (2013: 188) claims that unstressed vowels are more centralised. He also points out that it has been described in the literature that this reduction is sharper when speech rate is increased.

Correa Duarte (2017), in a study of Colombian Spanish with five male educated speakers, concludes that all unstressed vowels except for [i] are centralised. He also notes, that according to his values and others reported in the literature [a] can become similar to [ə] in American dialects of Spanish. On the contrary, both Torreira & Ernestus (2011) and Albalá et al. (2008) do not find evidence for vowel centralisation in their study, but rather less open articulations.

2.1.1.2.3 Intensity

Like formant structure, intensity is dependent on speaking style and individual differences; nonetheless, it is also possible to speak of different intrinsic intensities. As noted in Albalá & Marrero (1995), /a/ is intrinsically more intense than /e/ or /o/, which in turn present higher intensity than /i/ and /u/. In other words, the degree of aperture correlates positively with intrinsic intensity. But as can be inferred from their data, lip-rounding also seems to affect intensity, since rounded vowels, /o/ and /u/, present less intensity than their non-rounded counterparts, i.e. /e/ and /i/, respectively.

For the purposes of the present research, intensity in stressed vs unstressed positions is even more important than intrinsic intensity. Stressed is usually defined as a combination of different changes in acoustic parameters that, intermingled, create the perception of prominence for a given syllable. Stress, duration and changes in fundamental frequency usually interact in all languages to form such prominence, but the prominence of each factor is believed to be language-dependant. Stressed-triggered intensity differences have been here calculated from the data provided in Mora & Martínez (2015).

	[i]	[e]	[a]	[o]	[u]
Stressed	75.1	76.5	76	74	74.6
Unstressed	67.8	67.6	68.5	67.2	73.3
Diff. %	-10.77	-13.17	-10.95	-10.12	-1.77

Table 4: intensity differences in Spanish vowels; data from Mora & Martínez (2015).

As can be seen, the increase in intensity typically varies between 10% and 13%, except for /u/, with a minimal 1.77% change. Their data do not differ much from Albalá & Marrero (1995).

2.1.1.2.4 Duration

As mentioned before, segmental duration must not be confounded with the feature vowel length. Segmental duration also depends on several factors, for example, speaking rate, which presents not only inter- and intraspeaker differences, but also cross-dialect and cross-language differences.

		[i]			[e]			[a]			[o]			[u]		
Study	Prt	S	U	Dif%	S	U	Dif%	S	U	Dif%	S	U	Dif%	S	U	Dif%
2003/ChMe	3	101	71	42	122	72	69	126	94	34	120	83	45	118	80	48
2009/Cub	1	ND	ND	ND	69	63	10	ND	ND	ND	69	58	19	ND	ND	ND
2015/Ven	ND	112	96	17	111	88	26	116	96	21	120	92	30	111	90	23
2001/Sp	10	81	ND	ND	78	ND	ND	89	ND	ND	83	ND	ND	75	ND	ND
2004/Sp	5	80	54	48	76	56	36	86	65	32	73	54	35	68	49	39
1995/Sp	2	64	57	12	70	58	21	77	61	26	69	58	19	68	53	28

Table 5: vowel duration in the in the Spanish-speaking world.

Legend of table 5: ChMex = Chile and Mexico / Spa = Spain / Ven = Venezuela / Prt = number of participants / F = females / M = males / Or = Origin / S = Stressed syllable / U = Unstressed syllable / Dif.% Difference in %, to be read as "The vowel X is Y% greater in stressed position than in unstressed". Data from Cao (2003), Cervera et al. (2001), Madrid Servín & Santana Cepero (2009), Marín Gálvez (1995), Monroy Casas (2004: 33-44), and Mora & Martínez (2015).

Table 5 covers a smaller range of dialects than those reviewed for vowel structure, however, it is observable a general trend by which Spaniards tend to speak faster than speakers from other dialects. This trend has been observed in several works. Santiago & Mairano (2017) signal that Spaniards speak faster than Mexicans and Morrison & Escudero (2007) report that Spaniards produce substantially shorter vowels (33.9%) than Peruvian speakers, which is in line with the exhaustive literature review done in Schwab (2015). In her own work, comparing the speech rate of Costa Ricans and Spaniards, she also offers values that seem to indicate that Spaniards do speak faster than Costa Ricans, but she alerts that those differences did not reach statistical significance.

2.1.1.3 German Vowels

In this subsection, after a discussion about the total number of vowels that form the German inventory, an acoustic description of the German vowels will be provided; firstly, in terms of formant structure, secondly, in terms of duration, and thirdly, regarding their intensity.

2.1.1.3.1 Vowels with phoneme and/or allophonic status

Unlike Spanish, German has a very complex vowel system. In its standard version, it has 24 different vowel sounds (excluding diphthongs); 27 if the three nasal vowels are included (its presence in just a bunch of loanwords shows their lack of productivity). However, most authors agree on German having 16 phonemes, as will be later reviewed.

There are six pairs of tense and lax vowels that contrast in both length and quality, being tense vowels longer: /iː/ vs /ɪ/; /yː/ vs /ʏ/; /uː/ vs /ʊ/; /eː/ vs /ɛ/; /øː/ vs /œ/; and /oː/ vs /ɔ/. Additionally, there is controversy regarding the nature of the /aː/ vs /a/ contrast. Kohler ([2]1995: 170) defends that the two phonemes are differentiated solely by means of quantity, whereas Pätzold & Simpson (1997) note that, unlike in the rest of short and long pairs in German, the “chief difference” between these two sounds is one of duration and not of quality. Nonetheless, they also signal that in their own data, /a/ is slightly more central than its long counterpart.

Geographical variation has also been described; Russ (2010: 50) signals that /aː/ is “often retracted and rounded in southern Germany” ([ɑː]), whereas in the north it is more fronted. Similarly, he also signals that /a/ is fronted in northern Germany, whereas retracted and rounded in the south (Russ, 2010: 42).

In a similar vein, C. Hall ([2]2003: 86) also notes that in southern Germany /aː/ is actually a back vowel, but he adds that it has a certain amount of lip-rounding [ɒː]. On the opposite, the tendency in the north would be towards a more fronted position, noting even that it would be “rather similar in tongue position to the Southern British Standard [æ] as in *can*, but long”. Nonetheless, he also mentions that for many speakers /a/ is pronounced with exactly the same tongue position as for /aː/. Finally, T.A. Hall (2000: 34) notes that, although [a] is front in the IPA, it is actually rather central in German.

Apart of the above-mentioned 14 vowels, [ɛː] can also appear in stressed position. This sound is clearly anomalous because all other long vowels are both long and tense (and all short vowels are also lax), whereas [ɛː] is long and lax (as noted before, it is typically replaced by [eː] in the north). For southern speakers, [ɛː] is differentiated from [eː] by means of its distinctive quality, whilst from [ɛ] solely by means of length. The rest of the long vowels are contrasted by means of both features. For example, *m**ie**ten* [ˈmiːtən], or most frequently [ˈmiːtn̩], ‘to rent’, is tense and pronounced with a long vowel, whereas *M**i**tte* [ˈmɪtə] ‘centre’ is lax and pronounced with a short vowel. As can be seen, there is not only a difference in length, but also in vowel aperture. [iː] is long and close; whilst [ɪ] is short, mid-close, and more central than [iː]. Because of that, it has been argued that the real opposition in German vowels is not one of long vs short vowels, but between tense (Germ. *gespannt*) and lax (Germ. *ungespannt*) due to the different vowel qualities.

C. Hall ([2]2003: 77) points out the importance of tenseness as the main distinctive feature for German because vowel length heavily depends on the context in which they occur and on the nature of the vowel (open vowels are intrinsically longer). In other words, many concrete phonetic realisations of short vowels may perfectly have a greater duration than those realisations of long vowels, depending on which two vowels are being compared and on the intonational position and syllabic structure. As mentioned before, however, vowel length can be distinctive, as it is claimed to occur in Estonian (Asu & Teras, 2009).

Articulatory, it has been argued that tenseness and laxness is related to muscular tension, requiring tense vowels greater muscular energy than lax ones since they are produced on the edges of the vowel area, whereas lax vowels are articulated more towards the centre of the vowel area, i.e. the natural relaxed position for the tongue (C. Hall [2]2003: 76). Besides, he also provides indications to perceive these articulatory changes:

> If you pronounce these same two vowels in front of a mirror, you will notice how the muscles in the region of the lower jaw and the larynx contract for the tense [iː], but are relaxed for [ɪ]. You can also feel this difference in muscle tension if you put your thumb under your jaw while pronouncing [iː] and [ɪ] in succession.

He also notes that this difference is more visible in high vowels than in low, which goes in line with the fact that the tongue needs to move further upwards for high vowels, and therefore the contrast is more salient. On the contrary, T.A. Hall (2000: 27) alerts that investigations so far have neither corroborated that hypothesis nor rejected it.

Apart from the above-mentioned 15 phonemes (14, for those speakers without [ɛː]), there is one more sound with phonemic status despite appearing only in unstressed position (T.A. Hall, 2000: 68-70): [ə]. Thus, the total count of vowel phonemes in German is 16 (or 15 for most speakers in the north, where [ɛː] is mostly replaced by [eː]; C, Hall ^{2}2003: 84); if diphthongs are included, then it raises to 19, as in Kohler (^{2}1995: 169) or C. Hall (^{2}2003: 19).

Additionally, there are 8 more vowel sounds without phoneme status. All of them occur in unstressed position and one of them even serves to form minimal pairs. As noted in Russ (2010: 93), [ɐ] can be opposed to [ə] as in *bitt**e*** [ə] 'please' vs *bitt**er*** [ɐ] 'bitter', and yet, only [ə] is generally accepted to have a phonemic status, because such minimal pairs are scarcely productive. Furthermore, in view that these sounds alternate its realisation between a vowel and a consonant depending on syllable position, e.g. *Tie**r*** 'animal' [tʰiːɐ] vs *Tier**e*** 'animals' [tʰiːʁə] (T.A. Hall, 2000: 70), many authors prefer to treat it as vocalised allophone of the consonantal phoneme /ʁ/.

The other 7 vowel sounds without phoneme status in German are: [i], [e], [a], [o], [ø], [u], and [y]. C. Hall (^{2}2003: 76), considers that these "short tense vowels can be regarded as contextual variants of the tense vowel phonemes". According to this view, the long tense vowels have a short tense variant for unstressed position. Thus, the phoneme /iː/ has two allophones, [iː] and [i], the former in stressed position and the latter in unstressed position (typically in words of foreign origin such as *Kr**i**t**i**k* 'criticism', where the first vowel is close and short and the second one is close and long). These short tense vowels can also occur in some derivational suffixes, e.g. *lesb**a**r* 'legible' [a] (Russ, 2010: 55). Nonetheless, Russ (2010: 93) notes that "in the pronunciation of some speakers these shortened vowels become open and merge with the 'ordinary' short vowels [ɪ ɛ a o œ ʊ ʏ]".

Summing up, there are six pairs of vowels that are opposed in both length and vowel quality: /iː/ vs /ɪ/; /yː/ vs /ʏ/; /uː/ vs /ʊ/; /eː/ vs /ɛ/; /øː/ vs /œ/; and /oː/ vs /ɔ/; one more pair, /aː/ vs /a/ is certainly formed by means of length, but perhaps also by means of vowel quality, although less markedly than the rest. The tense members of these seven pairs also have a short contextual variant; they appear mostly in words of foreign origin: [i], [y], [u], [e], [ø], [o], and [a]. In addition, three more sounds complete the German vowel inventory. One of them is /ɛː/, which is special because it can be contrasted solely by means of either length (/ɛ/ vs /ɛː/) or quality (/ɛ/ vs /e/), although not across the whole country; the other two are [ɐ] and [ə], of which only the latter has phonemic status. Thus, the German vowel inventory is composed by 24 vowel sounds, excluding diphthongs and nasal vowels, out of which 16 (15 in the north) have phonemic status.

To conclude, it must also be noted that those 16 vowels are not equally distributed along the vocal space. As can be observed in figure 1, there are clearly more front vowels than back ones. Finally, it is also worth mentioning a typical characteristic of German which poses problems to many Spanish-speaking learners: lip-rounding or labialisation, whose acoustic correlate is F3. There are four pairs of vowels that share location on the vowel chart but are distinguished solely by the feature [±labialisation]. [iː] vs [yː], [ɪ] vs [ʏ], [eː] vs [øː] and, finally, [ɛ] vs [œ].

2.1.1.3.2 Formant structure

Anew, it must be mentioned that inter-study comparisons should be taken with caution, since the different methodologies affect the results. In what follows, data formant data from Fischer-Jørgensen (1990), Iivonen (1987), Pätzold, M. & Simpson A.P. (1997), and Sendlmeier & Seebode (2007) are presented for all German vowels.

Females	[iː]			[ɪ]			Participants
Study/Origin	F1	F2	F3	F1	F2	F3	
2007/Berlin	302	2533	ND	433	2095	ND	58
1997/North	329	2316	2796	391	2136	2867	12
1987/Wien	261	2738	3423	311	2613	3094	3
1990/North	224	2672	3400	348	2479	2883	1
Mean/all studies	279	2565	3206	371	2331	2948	74
Range/all studies	224-329	2316-2738	2796-3423	311-433	2095-2613	2867-3094	74

Table 6: vowel formants for [iː] and [ɪ] in the literature.

Females	[yː]			[ʏ]			Participants
Study/Origin	F1	F2	F3	F1	F2	F3	
2007/Berlin	320	1810	ND	426	1670	ND	58
1997/North	342	1667	2585	406	1612	2631	12
1987/Wien	301	1961	2406	340	1845	2527	3
1990/North	ND	ND	ND	ND	ND	ND	1
Mean/all studies	321	1813	2496	391	1709	2579	74
Range/all studies	301-342	1667-1961	2406-2585	340-426	1612-1845	2527-2631	74

Table 7: vowel formants for [yː] and [ʏ] in the literature.

Females	[eː]			[ɛ]			Participants
Study/Origin	F1	F2	F3	F1	F2	F3	
2007/Berlin	434	2461	ND	608	2040	ND	58
1997/North	431	2241	2871	592	1944	2867	12
1987/Wien	386	2712	3276	524	2315	2953	3
1990/North	339	2645	3071	453	2194	2830	1
Mean/all studies	398	2515	3073	544	2123	2883	74
Range/all studies	339-434	2241-2712	2871-3276	453-608	1944-2315	2830-2953	74

Table 8: vowel formants for [eː] and [ɛ] in the literature.

Females	[øː]			[œ]			Participants
Study/Origin	F1	F2	F3	F1	F2	F3	
2007/Berlin	440	1605	ND	564	1654	ND	58
1997/North	434	1646	2573	509	1767	2640	12
1987/Wien	425	1736	2609	563	1661	2649	3
1990/North	ND	ND	ND	ND	ND	ND	1
Mean/all studies	433	1662	2591	545	1694	2645	74
Range/all studies	425-440	1605-1736	2573-2609	509-564	1654-1767	2640-2649	74

Table 9: vowel formants for [øː] and [œ] in the literature.

Females	[aː]			[a]			Participants
Study/Origin	F1	F2	F3	F1	F2	F3	
2007/Berlin	896	1517	ND	836	1586	ND	58
1997/North	779	1347	2785	751	1460	2841	12
1987/Wien	862	1426	2834	869	1447	2779	3
1990/North	743	1355	2659	747	1688	2638	1
Mean/all studies	820	1411	2759	801	1545	2753	74
Range/all studies	743-896	1347-1517	2659-2834	747-869	1447-1688	2638-2841	74

Table 10: vowel formants for [aː] and [a] in the literature.

Females	[oː]			[ɔ]			Participants
Study/Origin	F1	F2	F3	F1	F2	F3	
2007/Berlin	440	889	ND	605	1200	ND	58
1997/North	438	953	2835	573	1174	2825	12
1987/Wien	414	825	2836	535	1048	2626	3
1990/North	ND	ND	ND	ND	ND	ND	1
Mean/all studies	431	889	2836	571	1141	2726	74
Range/all studies	414-440	825-953	2835-2836	535-605	1048-1200	2626-2825	74

Table 11: vowel formants for [oː] and [ɔ] in the literature.

Females	[uː]			[ʊ]			Participants
Study/Origin	F1	F2	F3	F1	F2	F3	
2007/Berlin	345	956	ND	442	1081	ND	58
1997/North	350	1048	2760	450	1184	2749	12
1987/Wien	314	846	2757	357	1001	2616	3
1990/North	ND	ND	ND	ND	ND	ND	1
Mean/all studies	336	950	2759	416	1089	2683	74
Range/all studies	314-350	846-1048	2757-2760	357-450	1001-1184	2616-2749	74

Table 12: vowel formants for [uː] and [ʊ] in the literature.

Females	[ɐ]			[ə]			Participants
Study/Origin	F1	F2	F3	F1	F2	F3	
2007/Berlin	ND	ND	ND	572	1763	ND	58
1997/North	590	1608	2829	420	1746	2811	12
1987/Wien	ND	ND	ND	ND	ND	ND	3
1990/North	ND	ND	ND	ND	ND	ND	1
Mean/all studies	590	1608	2829	496	1755	2811	74
Range/all studies	590-590	1608-1608	2829-2829	420-572	1746-1763	2811-2811	74

Table 13: vowel formants for [ɐ] and [ə] in the literature.

As mentioned before, patrimonial words mostly present either [ɐ] or [ə] in unstressed position. For this reason, few comparisons in the literature between formant values in stressed and in unstressed position can be found (Jessen, 1993; Mooshammer et al., 1999; and Mooshammer & Geng, 2008). Since this aspect will not be investigated in this dissertation, no details will be here provided.

2.1.1.3.3 Intensity

The literature on intensity in German is very scarce. Nonetheless, universals about intrinsic vowel intensity can, of course, be applied to German. For example, open vowels are cross-linguistically more intense, and German is no exception to that as can be seen in Geumann (2001: 328).

In Künzel et al. (1995), two graphics are provided, from which it is possible to infer that their male participants produced a mean intensity around 60 dB, whereas the mean intensity for female participants was slightly lower.

2.1.1.3.4 Duration

As for formant structure, the relation of the duration of a specific vowel between stressed and unstressed position has received very little attention in the literature owing to the fact that only [ɐ] and [ə] are typically found in unstressed position in patrimonial words; to my knowledge, only Jessen (1993) has investigated this issue. More relevant for German phonetics is the ratio between duration in tense and lax vowels. As noted before, tense phonemes are also long, whilst lax short.

Mooshammer et al. (1999) report that in stressed position the ratio between tense and lax vowels is 1:2.27. This value is consistent with the four values that Ramers (1988) provides for each of his four speakers (all of them from Nordrhein-Westfalen), whose ratios are 1:2.1, 1:2, 1:2.58, and 1:1.65. It also goes in line with Steinlen (2004: 83), who claims that tense vowels in her data are 100% longer. Finally, the 1:1.7 ratio reported in Strange & Bohn (1998), as cited in Steinlen (2004), is inferior to all above cited works except for one speaker in Ramers (1988). In all likelihood, the ratio is highly sensitive to interspeaker variation and intraspeaker variation triggered by speech rate, which was considered in Hoole et al. (1994). These authors found that the difference between tense and lax vowels is much greater in normal than in fast speech.

Finally, it is worth mentioning that duration is also affected by following segments. According to Heid et al. (1995), vowels were longer before plosives (mean duration 84 ms) than before fricatives and nasals (67 ms and 66 ms, respectively). Additionally, long vowels had a longer duration before voiced consonants than before voiceless ones.

2.1.1.4 Summary

There are important differences between the two languages regarding vowels. Firstly, Spanish lacks of a contrast between long and short vowels; secondly, it also lacks vowels occupying the central space like German [ɐ] and [ə]; thirdly, it has no phonemic contrast between rounded and unrounded vowels; and, finally, as reviewed in this section, Spanish does not present a constant allophonic distribution between close-mid and open-mid vowels.

This literature review of formant values for both German and Spanish reflects that Spanish vowels, contrary to what Navarro Tomás ([25]1991: 46-62) claimed, can be as open as those of German.

Females	F1 Mean	F1 Range	F2 Mean	F2 Range
German [iː]	279	224-329	2565	2316-2738
German [ɪ]	371	311-433	2331	2095-2613
Spanish [i]	354	256-420	2519	1981-2778
German [uː]	336	314-350	950	846-1048
German [ʊ]	416	357-450	1089	1001-1184
Spanish [u]	396	300-430	1022	600-1617

Table 14: mean values for comparable high vowels in Spanish and German.

Females	F1 Mean	F1 Range	F2 Mean	F2 Range
German [eː]	398	339-434	2515	2241-2712
German [ɛ]	544	453-608	2123	1944-2315
Spanish [e]	554	342-733	2215	1596-2557
German [oː]	431	414-440	889	825-953
German [ɔ]	571	535-605	1141	1048-1200
Spanish [o]	576	398-881	1322	959-2074

Table 15: mean values for comparable mid vowels in Spanish and German.

Females	F1 Mean	F1 Range	F2 Mean	F2 Range
German [aː]	820	743-896	1411	1347-1517
German [a]	801	747-869	1545	1447-1688
Spanish [a]	800	580-1020	1611	1321-1755

Table 16: mean values for open vowels in Spanish and German.

As can be observed in tables 14, 15, and 16, Spanish vowels present much wider ranges than German ones. Indeed, the ranges of one Spanish vowel occupy entirely or to a large extent the space of two German vowels (compare the ranges of Spanish /e/ with those of German /eː/ and /ɛ/). Secondly, a clear pattern can be observed: Spanish vowels are systematically more similar to German lax vowels. This is striking since lax vowels are more open than their tense counterparts.

Furthermore, it is possible to observe that, in many cases, not only can Spanish vowels be as open as German ones, but even slightly more. Likewise, it is also true that Spanish vowels can also be as close as the German tense vowels. All in all, Spanish vowels present ranges that are extremely broad compared to those of German, which is to some extent to be expected, since the number of vowels with phoneme status is much lower in Spanish.

2.1.2 Stops

Stops are sounds realised by means of a complete closure that interrupts the flux of air and its subsequent release. Thus, they are different in nature to fricatives, whose production allows the flux of air, albeit impeded due to a constriction in the vocal cavity and its resulting friction.

Martínez Celdrán & Fernández Planas ([2]2013: 31-33) describe the articulation of stops in three phases: 1) implosion, 2) occlusion, and 3) explosion. The first refers to the moment in which the active articulator(s) get(s) in motion to adopt the corresponding contact gesture; the second is the occlusion itself, i.e. it is the phase in which the organs remain sealed impeding the air to pass through, which increases the air pressure. Finally, the air pressure overcomes the tenseness that keeps the closure and the air rushes out more or less violently.

Baart (2010: 77) also acknowledges a difference in air pressure, namely between the two sides of a closure in the vocal tract but seems to imply a more active role by part of the speaker for the third phase, since he mentions a “release” of the closure, which causes “a sudden stream of air”. In turn, Ladefoged

([3]1993: 8) does not enter into details and simply states that "when the articulators come apart, the airstream will be released in a small burst of sound". In all cases, what is clear is that owing to the air blockage, the air forms a little explosion or burst.

Notwithstanding, the only essential phase for the stop production is the second, i.e. the closure; see Martínez Celdrán & Fernández Planas ([2]2013: 31-33) for cases in which phase 1 or 3 are missing (and which are out of the scope of this dissertation).

Regarding their place of articulation, stops in German and Spanish present minimal differences, if any. In both languages /b p/ and /g k/ are traditionally considered as bilabial and velar stops, respectively, but recent articulatory data (with a small sample of speakers) move backwards the articulation point of /g/ and describe it as uvular in Spanish (Iribar et al., 2016).

/t d/ have been traditionally considered dental in Spanish (Hualde, 2005: 45), but are now said to be dento-alveolar after recent articulatory studies (Fernández Planas & Martínez Celdrán, 1997). As for German, Russ (2010: 67-69) classifies them as alveolar, but his description implies dento-alveolar contacts ("the sides of the tongue lie against the upper teeth". Kohler ([2]1995: 159), in turn, states that "apical sounds are produced either in the dental or in the alveolar area".

Apart from the activity in the oral cavity, there activity in the glottis is also important in stops production. Depending on the type of activity in the glottis, stops in Spanish and German will be voiced lenis, unaspirated voiceless lenis, unaspirated voiceless fortis, or aspirated voiceless fortis.

For Spanish and German, three different features have been proposed to account for the different phonetic outcomes resulting from glottal activity, namely voicing, aspiration, and tenseness. In the following subsections, a review of these phonetic features will be provided, and, by so doing, the exact sense in which these terms are used throughout this thesis will be clarified. Thereafter, stops will be presented in both German and Spanish, outlining their different phonetic realisations sorted out by phonetic context.

Finally, it is also worth mentioning that there is a recurrent stop in German without phonemic status: the glottal stop [ʔ]. Unlike the rest of the stops, its closure is not produced in the oral cavity, but in the glottis (its active articulators are the vocal folds). It usually appears before or between vowels, but also affects plosives regularly by means of either actual glottal stops or glottalisation processes (Kohler, 2001). No further details will be here provided as the contexts in which glottal stops and glottalisations occur will not be dealt with in this investigation.

Voicing

Voicing is perceived categorically, i.e. listeners perceive sounds as either voiced or voiceless, and is produced by means of the vibration of the vocal folds. Such vibration is produced at the glottis alongside with a cavity enlargement (Kohler, 1984), which has the effect of allowing the vocal folds to vibrate.

As noted in Ladefoged & Maddieson (1996: 51), voiced stops require more energetic efforts than voiceless ones because of the need to produce sustained vocal fold vibration.

Depending on the phonetic context, one segment can be partially or fully voiced/devoiced. For example, an intervocalic [k] can be partially voiced at the onset and/or the offset, in that case, it can be transcribed using the correspondent IPA diacritic [k̬]. Unfortunately, diacritics do not allow us to discern among stops according to their voicing/devoicing degree. If such details are required, one needs provide numeric data with the percentage of voicing during the production of this sound. Likewise, consonants can be devoiced, in which case its correspondent IPA diacritic can be used, e.g. [b̥ d̥ g̊], or again, provide numeric data for the percentages of voicing activity.

Beckman et al. (2013) distinguish between active and passive voicing. These authors consider passive voicing to be a consequence of voiced contexts, i.e. the voicing of one segment simply overlaps part of an adjacent one, instead of being the result of active gestures.

In the acoustic analysis, it is possible to see how active voicing is constant in amplitude throughout the segment; on the contrary, voicing amplitude decreases gradually when the voicing is passive. Despite its gradual decline, passive voicing can be maintained throughout the whole closure or not (see figures 2 and 3 in their paper, for spectrograms with examples of passive voicing fading away before the release and active voicing, respectively). According to these authors, Spanish would be a language with true voicing, whilst German would exemplify passive voicing.

A side effect of voicing is reported in Jessen (1998: 271); according to him, voiced stops will typically present lower intensity during the burst given that a relatively low amount of oral pressure is necessary so that voicing can be sustained (but see Melo et al. 2014 with findings contradicting this claim).

Finally, it is also worth noting that voicing might not have solely an effect in the involved stop, but also on the following vowel. Kohler (1982), Jessen (1998: 310), and House & Fairbanks (1953) report higher F0 after fortis sounds.

Similarly, Kirby & Ladd (2016), after a cross-linguistic investigation (French, Italian, and English), have found that F0 is depressed during the closure phase of a voiced obstruent, "which is consistent with known laryngeal adjustments which sustain phonation". Conversely, F0 is raised after the release of a voiceless consonant, which "can be understood as the result of laryngeal adjustments to inhibit phonation". In sum, Kirby & Ladd (2016) conclude that "F0 perturbations are fundamentally the result of laryngeal manoeuvres initiated to sustain or inhibit phonation, regardless of other language-particular aspects of phonetic realisation".

Aspiration

According to Ladefoged & Maddieson (1996: 70), aspirated sounds are produced with the vocal folds markedly further apart than they are in modally voiced sounds. For Kim (1970), the glottis is especially spread in aspirated sounds, i.e. there is an active movement. In other words, aspirated stops do require extra muscular activity in order to spread the glottis more than in any other sound.

Ladefoged & Maddieson (1996: 70) define aspiration as "a period after the release of a stricture and before the start of regular voicing (or the start of another segment, or the completion of an utterance)". Jessen (1998: 76, 80-81) works with a slightly different criterion and marks the onset of the second formant as the end point for aspiration. The prefer to focus on the end of the turbulence rather than on voicing onset.

Aspiration is quantified by means of Voice Onset Time, henceforth VOT, which is a well-established term in the field of acoustic phonetics coined by Lisker & Abramson (1964). Its use is of particular interest for this research, because it also allows quantifying voicing duration, and thus facilitates the comparison between languages that use different primary features ([±voicing] for Spanish, and [±aspiration] for German).

VOT can be defined as the time between the release of a stop consonant and the onset of voicing (Cho & Ladefoged, 1999), and is usually expressed in milliseconds. According to Lisker & Abramson (1964), voicing can begin before the release, short after the release, and considerably behind the release. If there is already voicing before the release, the value is negative.

Although VOT values are sometimes categorised as voiced, short lead, and long lead, they are always expressed in numerical values, which is more suitable to reflect gradience in the output.

Short lead stops [p t k] are usually referred to as unaspirated in opposition to [p^h t^h k^h]. Strictly speaking, this statement is only valid in phonological terms, since there is always some degree of aspiration in [p t k].

Despite the usefulness of VOT to measure both voicing and aspiration, it has some limitations. For example, a stop whose closure is divided into a portion with passive voicing and another one without voicing at all would be problematic to capture solely in terms of VOT. If the passive voicing is taken as the starting point to measure VOT, the resulting numeric value will mask that there is no voicing throughout the whole segment. If, on the contrary, this passive voicing is excluded, the resulting VOT value will be positive, and, thus, will also fail to reflect the linguistic reality. For those cases, measurements of VOT should be complemented with reports of voicing percentages throughout the closure.

A further limitation of VOT is that it only provides information about the time dimension of the movement in the vocal folds. Therefore, it does not allow us to discriminate between totally devoiced stops [b̥ d̥ g̊] and voiceless ones [p t k], owing to the absence of voicing in both series (VOT in Alemannic can be identical for these two series; Fulop, 1994). In order to discriminate acoustically between [b̥ d̥ g̊] and [p t k], it is important to measure the acoustic correlates of the feature tenseness, which will be explained in the following section.

Apart from VOT, other acoustic measurements are sometimes applied to study aspiration, which can be viewed as fricative noise, and, therefore, subject to acoustic measurements typical from fricatives; namely the spectral moments (see fricative section). An example of a study following this approach is Chodroff & Wilson (2014).

Lastly, it is worth mentioning that as a side effect of aspiration, following vowels are produced with breathy voiced (Jessen, 2012: 255). This is not triggered by the turbulence itself, but by the spreading of the glottis. However, since aspirated sounds present a wider glottis opening than any other sounds, in practice, aspirated sounds will be most affected.

Jessen himself (1998: 111-115 & 312) reports his own results and concludes that German fortis [p^h t^h k^h] and lenis [b̥ d̥ g̊] differ significantly in the amount of breathy voice in the following vowel. The method used by Jessen (1998: 110-111) to calculate the degree of breathiness was calculating the difference in amplitude between the first and second harmonics; the advantages and disadvantages of that method and those of others also commonly used are summarised in Gordon & Ladefoged (2001).

Breathy voice, sometimes called murmured voice, is produced “if the vocal folds are held together only loosely” (Ladefoged, ^{2}2005: 140-142). As also noted by this author, “the waves corresponding to the formants are not so obvious”, and there is also lower amplitude during breathed segments.

As noted, phonologically unaspirated consonants are indeed phonetically slightly aspirated, i.e. thus, a minor degree of breathy voice is expected to occur. Gobl & Ní Chasaide’s data (1988: 53) corroborate this. It is also worth mentioning that, according to their data, breathiness affects more the preceding than the following vowel. Lastly, it is worth mentioning, that the degree of change from modal voice to breathy voice is, to some extent, language dependent. In Jessen’s review of this phenomenon (1998: 109-110), it is claimed that breathy voice has been documented in several Romance and Germanic languages, but apparently would be stronger in German.

Tenseness

Based on this feature, sounds can be either fortis or lenis (sometimes referred to as tense and lax, respectively). The main acoustic correlate of this feature is seemingly the ratio between closure and vowel duration.

Hardly ever is tenseness the primary distinctive feature between two series of stops. In this regard, it is worth bringing back the above-mentioned case of Alemannic. At least in its Zurich and Thurovingian varieties, it is claimed to distinguish between two series of stops simply by means of the feature tenseness; see Kraehenmann (2001), Fleischer & Schmid (2006), and especially Fulop (1994). The latter author even suggests that in absolute initial position (where closure duration cannot be measured) formant features "may be sufficient" to distinguish the two series. If this guess were confirmed, it would be highly relevant since, among all the phonetic characteristics associated with the feature tenseness, closure duration has been claimed to be the most salient (Kohler, 1979). In any case, even if fortis could not be perceived differently from lenis in initial position, Alemannic is still a rare case in which closure duration, i.e. the fortis/lenis distinction, is enough to contrast phonologically two series of stops.

The feature tenseness is also claimed to play a crucial role in Korean; in initial position, stops are said to be either a) voiceless unaspirated lenis, b) voiceless unaspirated fortis, and c) voiceless aspirated fortis (Shin et al., 2013: 34). However, this claim seems to be more supported on phonological grounds than in phonetic ones. As noted by the same authors (Shin et al., 2013: 61), the theoretically voiceless unaspirated lenis are frequently realised with aspiration (although less than phonologically aspirated stops). Furthermore, pitch also seems to play a role in the distinction Korean stops; Shin et al. (2013: 63) and Kim & Duanmu (2004).

There is no specific IPA diacritic to indicate that a sound is fortis or lenis. In this dissertation, Fleischer & Schmid's (2006) notation for Alemannic has been followed, i.e. [b̥ d̥ g̊] refer to ***totally*** voiceless lenis sounds. This goes not without problems, since as mentioned before, the same symbols are also used in other languages when it is considered that [b d ɡ] have undergone only ***partial*** devoicing. The rationale behind the decision of following Fleischer & Schmid (2006) is to be able to distinguish Spanish [p t k] from German [b̥ d̥ g̊].

As mentioned, most languages rarely contrast different stops solely by means of the feature tenseness, which poses several methodological problems for the acoustic (and articulatory) definition of this feature. If we admit that fortis co-occurs with aspiration in some but not all languages, and lenis co-occurs with voicing in some but not all languages, then it follows that we could be confounding factors when studying the acoustic correlates of fortis and lenis sounds in languages in which tenseness is just a secondary feature. It must not be forgotten that fortis only indicates that the closure of this sound will be longer than in its lenis counterpart, however, the exact phonetic realisation of this sound will depend on the interplay with voicing and aspiration. Thus, in German fortis will refer to [p^h t^h k^h], whereas in Spanish fortis refer to [p t k].

In order to separate the intrinsic characteristics of tenseness from those of voicing and aspiration, it is useful to examine cross-linguistic evidence. Regardless of the exact phonetic realisation, i.e. with presence or absence of voicing and aspiration, a vast amount of evidence has proved that fortis sounds are characterised by presenting a longer closure duration (Fischer-Jørgensen, 1976; Melo et al., 2014; Zampini & Green, 200; Martínez Celdrán, 1991; Jessen, 1998: 307; but see also Kuzla & Ernestus, 2011).

Likewise, next vowel is usually shorter after a fortis stop than the same vowel when followed by its lenis counterpart (Kuzla & Ernestus, 2011; House & Fairbanks, 1953; and Allen & Miller, 1999, for English; or Melo et al., 2014, for Portuguese). The same trend has been observed for preceding vowels (Piroth & Janker, 2004).

Lastly, it is unknown whether tenseness triggers F0 chances and/or breathy voice. Due to the special status of this feature in Alemannic, more studies on this language are needed would shed some light on this topic.

Perhaps more frequently, the labels fortis and lenis are also used to refer to articulatory differences, sometimes with a rather vague meaning. As mentioned, depending on the language under scrutiny, fortis can be used as a synonym for both aspirated or for unaspirated voiceless stops, whilst lenis as a synonym for voiced or unaspirated stops.

Fortis consonants have been claimed to be produced with greater energy (Russ, 2010: 27). According to this author (Russ, 2010: 65), there is a greater volume of air expelled after the release of the occlusion and the greater muscular tension of the lip in the case of [p] is also stronger than in comparison to [b][3]. C. Hall ([2]2003: 28) compares lenis [b̥ d̥ g̊] with fortis [p t k]. Because of the difference in tenseness, he argues that they are different even if [b̥ d̥ g̊] are fully devoiced. In turn, Ladefoged & Maddieson (1996: 96) note that there is larger lip compression when producing fortis [p] than lenis [b]; likewise, fortis [t] is produced using a greater contact area than homorganic lenis [d]; Engstrand (1989). Lastly, Kohler (1981b) links the above-described duration characteristics of both stop closure and preceding vowel with the articulatory mechanisms involved in the productions of fortis and lenis sounds. He notes that in the fortis sounds, there is "a muscular activity which is quickly built up and then decreases slowly". This activity is responsible for causing "a fast closing and a subsequent slow opening movement". On the contrary, in the lenis sounds, the muscular activity "sets in later and is checked by a rapid decrease resulting in a slow closing and a subsequent fast opening movement". Finally, he concludes that closure and vowel duration are thus simply the outcomes of these differences in the timing of muscular activity.

As noted, the term lenis can be applied both to [b d ɡ] and [b̥ d̥ g̊], depending on which language we are talking about. Since active muscular activity is required to produce the necessary cavity enlargement to produce voicing, the term lenis would be thus not entirely satisfactory (Steinberg, 2008: 27) when referring to [b d ɡ].

[3] His used of [p] and [b] for German corresponds to [pʰ] and [b̥] in this dissertation.

From a purely acoustical point of view, there is no such contradiction, since closure duration lasts longer in fortis than in lenis sounds. It is in this sense that the labels fortis and lenis will be used throughout this thesis, since both [p t k] and [p^h t^h k^h] present a longer closure than [b d g] and [b̥ d̥ g̊], respectively.

Finally, it is important to note that German and Spanish present some contextual differences in stops production. For the sake of comparability, two contexts have been chosen to structure the subsections on German and Spanish: absolute initial position and intervocalic position. The rest of phonetic contexts (e.g. consonant clusters with other stops, with nasal or lateral plosion, or codas) will not be reviewed since they were not included in the analyses.

2.1.2.1 German stops

As mentioned before, stops will be reviewed only in absolute initial position and intervocalic position. However, a further subdivision between word-initial intervocalic position, and word-medial intervocalic position will be made for German, following Jessen (1998).

2.1.2.1.1 Absolute initial position

For this position, standard German contrasts primarily by means of the feature [±aspiration], and, secondarily, also by means of tenseness.

Thus, there is a contrast between [p^h t^h k^h], which are aspirated and fortis, and [b̥ d̥ g̊], which are unaspirated and lenis. However, as can be inferred from Jessen (1998: 87), some speakers do produce voicing in absolute initial position, i.e. [b d g] instead of [b̥ d̥ g̊].

Indeed, his data from six northern Germany speakers suggest it is possible to speak of a probabilistic distribution for the lenis sounds. One of his speakers produced nearly all his lenis stops with voicing, two never made use of voicing, other two produced 40% of the tokens with voicing, and one more only in 25%. These results show a wide range of variability for speakers with the same geographical background. Despite this occasional voicing, it is still perfectly possible to consider aspiration as the main perceptual cue, since all participants produced fortis stops with aspiration (Jessen 1998: 307). As reviewed by Jessen (1998: 43), pronunciation dictionaries indeed prescribe aspiration for this position. However, according to Russ (2010: 66-70), there is some deal of geographical variation; in his work, initial fortis stops are claimed to be pronounced with little aspiration or none in southern Germany. Additionally, without offering acoustic data, he signals the existence of vibration “immediately before the release”.

Neither geographical information nor mean values are provided in Haag (1979), whose study employed a single speaker of “High German”. He does include, however, a report on each token realisation, which allows us to see how large intraspeaker variability in the degree of aspiration can be. Interestingly, his VOT values for [t] are lower than for [p], which goes in line with Stock (1971), and clearly contradicts the typically found pattern (e.g. Lisker & Abramson, 1964), whereby [p] is less aspirated than [t], which in turn is less aspirated than [k].

Shinn (1985: 335) reports data on three participants, two from Cologne and one from Flensburg. One participant uses voicing for lenis stops in utterance-initial position, whilst the other two do not. The participants in Mayer (1994: 101-103) produced fortis stops with long lead, whilst lenis ones with short lead, except for two out of 10 participants, who generally presented long voicing, but occasionally also short lead stops (Mayer, 1994: 57-58). A third one produced voicing only for [b] (that voicing is more naturally trigged for [b] is also attested in Ouddeken's, 2016, figures 2, 3, 9, and 10).

Ouddeken (2016) analysed data from different databases, none of them refers to Standard German, but to the northern "dialects". Standard German has replaced to a large extent all varieties of the autochthonous language: Low German. However, these Low German varieties have exerted a profound influence on Standard Germany, as its standard pronunciation basically reflects that of the northern speakers; Sanders (1982: 189-190), Siebenhaar (2011), or Kohler ([2]1995: 38-39), to cite just a few. Therefore, it is worth having a look at the voicing contrast in initial position in these regions, even when not referring specifically to Standard German. According to Ouddeken, although it is not the prevalent pronunciation, voicing does regularly occur in northern Germany lenis stops.

More data on standard German are provided in Gabriel et al. (2018). Their monolinguals' values for the fortis series are considerably more aspirated than those of Jessen (1998). [p t k] are produced with approximately 70, 79, and 95 ms of VOT, respectively; for [b d g] no instance of negative VOT was produced and the reported means are 15, 22, and 29, respectively.

Hamann & Seinhorst (2016) also report evidence of voicing even in initial position. Their speakers are from Konstanz and Düsseldorf (5 participants from each region), and it is explicitly stated that they spoke no dialect. Their participants uttered plosives in utterance-initial position with considerable variation in the realisation of /b d g/; both inter- and intraspeaker. According to the authors, "in stressed onsets before /a/, 7 out of 10 speakers variably prevoiced these categories (52.5% of their tokens, average VOT of the prevoiced tokens -95.2 ms), and 1 out of those 7 speakers prevoiced all their tokens without exception".

Summing up, it can be concluded that, although aspiration is the main perceptual clue in this position, voicing seems to co-occur with lack of aspiration more often than previously assumed. Lastly, speakers with the same geographical background differ greatly in their realisations, and the data seem to indicate stronger interspeaker than intraspeaker variability.

2.1.2.1.2 Intervocalic word-initial position

Apart from in absolute initial position, word-initial stops can also occur intervocalically. Differentiating between these two contexts is relevant, voicing occurs with greater frequency in this position (Jessen, 1998). Likewise, Pape & Jesus (2015) note that the voicing-possibility is much higher in word-medial intervocalic position than in word-initial intervocalic position. Additionally, these authors also report a vowel effect, with low vowels decreasing the voicing probability.

Intervocalic word-initial position is the context typically found in many VOT studies, which use words embedded in a sentence; e.g. for example, *ich sage X nochmal/wieder*[4] 'I say X again'.

This is precisely the case of Chionidou & Nicolaidis (2015), who reported data on children aged 8 to 12 producing fortis stops with 59 [p], 65 [t], and 69 [k] ms of VOT. Interestingly, they provide the exact percentage of tokens produced with voicing for lenis stops: 24%. Andreeva & Wolska (2011) also provided voice-ratio indexes for German word-initial stops after a vowel. Interestingly, lenis stops are almost fully voiced, whilst fortis ones only slightly. Fischer-Jørgensen's data (1976: 158), as cited in Jessen (2004), reveal that /b d g/ in this position are "normally partly voiced, but there is a large variation between subjects and also in the recordings of the same subject and the same word". Voicing portions ranged from 14% to 75% during the closure. Lastly, in Beckman et al. (2013), the hitherto unpublished individual data for voicing percentage of the six speakers of Jessen (1998) are reported. In their data, the voicing % during closure varies extremely from one speaker to another, from less than 20% to more than 80%, but there does not seem to be intraspeaker variation.

All in all, it seems clear that the degree of voicing for /b d g/ is greater than in utterance-initial position. However, all studies reflect that interspeaker variability is enormous.

2.1.2.1.3 Intervocalic word-medial position

For this position, German is usually said to contrast between voiced and voiceless sounds (C. Hall, [2]2003: 27). Jessen (1998: 57-58 and 67), in turn, notes that also aspiration serves to contrast between the two series of plosives. However, according to his review, there is greater variability in the degree of aspiration than in that of voicing.

Fischer-Jørgensen's data (1976: 159), as cited in Jessen (2004), reveal that /b d g/ are, in this position, "often fully or almost fully voiced, with decreasing amplitude of the vibrations". Yet, there seems to be considerable intraspeaker variability. According to Künzel (1977), as cited in Jessen & Ringen (2002), 12 out of 26 participants produced lenis stops with less than 50% of voicing during the closure.

Moreover, Jessen & Ringen (2002) report that, unlike males, their female participants did not constantly present fully voiced lenis stops in intervocalic. The authors defend that intervocalic voicing typically occurs, but not always because of the passive nature of the voicing. In their view, what is crucial in the

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[4] German speakers often drop the final schwa in *sage* and, consequently, produced /g/ as [k] since all coda stops are voiceless. If participants are not explicitly told to avoid such pronunciations, this difference in pronunciations could account for some of the voicing/devoicing of the following stop.

contrast between /p t k/ and /b d g/ is that the first series is produced with spread glottis (so that aspiration is produced), whilst the second is not. Additionally, fortis stops have longer closures (Jessen, 1998: 92) and the following vowel is produced with breathier than after lenis stops (see Jessen, 1998: 104, for an articulatory explanation).

More modern studies, like that of Gabriel et al. (2016), also confirm the importance of aspiration in this position. These authors recruited 10 German monolingual teenagers in Hamburg, whose VOT means in word-medial position reflect the expected contrast between presence and lack of aspiration for /t/ and /d/, respectively.

In sum, aspiration typically appears in fortis consonants in this position, whilst voicing typically appears in the lenis series, but not necessarily covering the whole closure period, and decreasing in amplitude, i.e. it is typically passive. Finally, closure duration and breathy voice in the following vowel also provide acoustic aid for the discrimination of /p t k/ and /b d g/.

2.1.2.2 Spanish stops

The most striking difference with German stops is that /b d g/ are not always realised as stops; indeed, the most frequent realisation is as approximants. A stop realisation in /b d g/ is reserved for absolute initial position, after nasals, and, in the case of /d/, also after a lateral (Hualde, 2005: 139), but everywhere else, the approximant appears. In addition, /p t k/ are also typically pronounced as approximants in codas.

A further difference with German is that when intervocalic stops present the same phonetic form both word-initially (e.g. *una bata* 'a housecoat') or word-medially (e.g. *abandonado* 'abandoned'); these contexts will therefore be exposed together.

2.1.2.2.1 Absolute initial position

Unlike in German, in which voicing is relatively infrequent in this position, the vocal folds consistently vibrate for /b d g/, which serves to contrast with /p t k/. To my knowledge, only Castañeda (1986) has documented few exceptions to this pattern. In her study, the existence of "some cases" in which /g/ is produced with no voicing before the release is reported in her concluding remarks. In turn, /p t k/ are produced in Spanish with minimal aspiration. Both series are thus phonetically represented as [b d g] and [p t k].

A further difference is that [b d g] are lenis and [p t k] fortis. Consequently, closure duration is longer in the latter, whilst vowels are longer after [b d g]; see Martínez Celdrán & Fernández Planas (^{2}2013: 63-85) for a discussion on tenseness in Spanish treating these aspects and others, although not specifically related to utterance-initial position.

Typical VOT values reported in the literature do not seem to reflect diatopic variation (table 17).

Study	Origin	[p]	[t]	[k]	[b]	[d]	[g]
Castañeda (1986)	Spain	6.5	10.4	25.7	-69.8	-77	-58
Asensi et al. (1997)	Spain	9.1	13.2	21.2	ND	ND	ND
Lisker & Abrahmson (1964)	Puerto Rico	4	9	29	-138	-110	-108
Villamizar (2002)	Venezuela	17.43	19.22	32.24	-43.81	-51.27	-47.2

Table 17: VOT values in Spanish in utterance initial plosives.

As can be observed, [p] presents a shorter VOT than [t], which, in turn, is also shorter than that of [k]. This pattern not only corresponds with the general one found cross-linguistically, but also with the articulatory data reported in Martínez Celdrán & Fernández Planas ([2]2013: 68). According to these authors, the glottis is most spread for [k], then [t] and finally [p].

2.1.2.2.2 Word-initial/medial intervocalic position

Spanish /b d g/ and /p t k/ contrast more markedly intervocalically than in absolute initial position, since they present different manners of articulation: the former are approximants [β̞ ð̞ ɣ̞], whereas the latter stops [p t k]. This complementary distribution is Pan-Hispanic with very few exceptions; Hualde (2005: 113) mentions that in some areas in Colombia and Central America plosives can be found after all consonants and even after glides.

These approximant sounds were originally described as fricatives (Navarro Tomás, ([25]1991: 19; Quilis, [11]2012: 13), but after the introduction of the sound-class *approximant*, they were reinterpreted as such, and there is a now well-established consensus to classify those sounds as approximants (Hualde, 2005: 141; Celdrán 1991).

Notwithstanding, it is still customary for many authors to employ the symbols for the corresponding fricative sounds, i.e. the same symbols but without the diacritic [β ð ɣ], even when explicitly signalling that they are approximants. Such tradition will not be respected throughout this thesis for different reasons. Firstly, because there are no typing and printing constraints anymore that justify the use of those inaccurate symbols; secondly, because its use may be misleading for those who have a solid knowledge of general phonetics but not of Spanish in particular.

Before dealing with the acoustic description of these sounds, it is worth dedicating some lines to briefly define the concept of approximant. Following Martínez Celdrán (2013), approximants can be defined as segments which present a certain constriction degree, but in which no turbulent airstream is produced owing to a lack of articulatory precision. This lack of articulatory precision can occur if the vocal tract is not sufficiently constrained, as a result of insufficient tension in the articulatory organs, or a combination of both.

His definition presents only a minor departure from Ladefoged's definition ([3]1993: 292); according to this author, approximants are produced when an articulator is close to another but without presenting a constriction narrow enough that would produce a turbulent airstream.

/b d g/ in word-initial/medial intervocalic position

Martínez Celdrán (2013) provides, to my knowledge, the most exhaustive acoustic characterisation of approximants in Spanish. This author, in a study with three participants, distinguishes three possible types of approximants, namely open, closed, and vocalic; what he terms as open approximants are, by far, the most common realisation in his study and therefore its prototypical form. Closed approximants present some silence, like plosives, in the upper frequencies, but no explosion; whereas vocalic approximants are those whose limits are extremely fuzzy and only a minor change in intensity can be detected in comparison to adjacent vowels. In these cases, it is impossible to mark objectively when the sound begins and ends, but it is possible to conclude that the intensity minimum is the centre of vocalic approximants. Furthermore, open approximants, present a structure of transitional formants between vowels, apart from the typical decrease in duration and intensity. Lastly, the author also opposes the three types of approximants to fricatives owing to the absence of noise.

The acoustic data provided in his work signal that these approximants[5] are generally 44.60 ms long (9.69 SD) and have an intensity of 71.44 dB (3.62 SD), which represents a difference with the surrounding vowels of 5.45% (2.87 SD).

/p t k/ in word-initial/medial intervocalic position

It is traditionally assumed that /p t k/ are produced as voiceless stops in these contexts. Besides, VOT measurements have been said to be equal to those of utterance-initial position; Asensi et al. (1997). Indeed, data for this position (Poch, 1984) are largely in line with table 17.

However, both Martínez Celdrán (2009), Hualde et al. (2011), and Torreblanca (1976) provide exhaustive references covering most dialectal areas and confirming that /p t k/ become partially or fully voiced in intervocalic position with much more frequency than previously thought.

Hualde et al. point out that this phenomenon is particularly pervasive in Cuban and Canarian Spanish, but most relevant for this study is that in Toledo (Torreblanca, 1976) and Madrid (Torreira & Ernestus, 2011), where most of the monolingual speakers come from, this phenomenon is also frequent.

Moreover, Martínez Celdrán (2009) in a study with a single speaker from Murcia (Spain), Hualde et al. (2011) with data from 20 Majorcan participants (Spain), Torreira & Ernestus (2011) with 20 speakers from Madrid, and also Machuca Ayuso (1997) according to Hualde), have documented not only the sonorisation of the voiceless stops, but also its lenition into [β̞ ð̞ ɣ̞]. It must be noted, though, that approximants realisations for /p t k/ just accounted for 15.85% of the total realisations of Martínez Celdrán's participant. According to Martínez Celdrán & Fernández Planas ([2]2013: 82), in Machuca Ayuso's study (1997) with speakers from Barcelona, 40% of /p t k/ tokens were voiced, an only 9%

[5] These data correspond to his so-called "open approximants" (that account for 86.9% of his data).

thereof approximants. In Torreira & Ernestus (2011) a quarter of the voiceless stops were realised as approximants. Finally, in Hualde et al. (2011) 22% of the /p t k/ tokens in spontaneous speech are voiced, and an additional 13.6% partially voiced.

In some cases, the proportion of voiced /p t k/ tokens and its more radical lenition into approximants is relatively low, which reduces considerably the cases of apparent total phonetic merging. In other cases, e.g. Machuca Ayuso (1997), some speakers attain voicing percentages of 64.6 (as cited in Hualde et al., 2011). Hualde et al. also signal the large interspeaker differences in their sample, in which four of their speakers also voice /p t k/ with a 60% frequency.

With such high percentages of voicing and lenition into approximants (for some speakers) an obvious question arises: is there any phonetic cue that allows listeners to discriminate between /p t k/ and /b d ɡ/ even in these cases of apparent total merging?

Martínez Celdrán (2009) explicitly denies the possibility of duration being the acoustic clue that would still enable phonological discrimination between the two series of stops. In his study, voiceless stops had a mean duration of 91 ms, the semi-voiced stops 85 ms, voiced stops 65 ms, and, finally, approximants 51 ms, but when a voiceless stop underwent full voicing, it became indistinguishable from /b d ɡ/ in terms of duration. Likewise, when it was lenited to an approximant, no differences in duration were found. This led the author to defend that tenseness is the distinctive feature, of which duration can be an acoustic clue, but not necessarily. Hualde et al. (2011), on the contrary, did find differences in terms of duration and intensity between /b d ɡ/ and voiced realisations of phonemic /p t k/.

All in all, it can be concluded that /b d ɡ/ and /p t k/ canonically contrast in both manner of articulation and voicing: /b d ɡ/ are voiced approximants, whereas /p t k/ are voiceless stops. Not infrequently, the contrast is less robust, since /p t k/ become partially or fully voiced. Lastly, sometimes the contrast is jeopardised, since /p t k/ become even lenited into approximants. This last scenario is seemingly unusual for most speakers.

2.1.2.3 Concluding remarks

Monolinguals are far from producing totally homogenous phonetic realisations of stops in both German and Spanish, even when belonging to the same dialectal area. Moreover, intraspeaker variation is considerable. Some of these pronunciations departing from the general pattern have important implications for a study like this, in which monolingual speakers are used as control group. If even German monolingual speakers present occasional voicing in absolute initial position, sporadic voiced realisations in the bilinguals will not suffice to claim that bilingualism is affecting the speech of those speakers. Even though a transfer from Spanish voicing may sound plausible, such a claim can only be sustained if voicing appears in the German speech of these bilinguals more recurrently than it does already in the monolingual population. It is also worth commenting the articulatory overlap produced in utterance-initial stops of both languages.

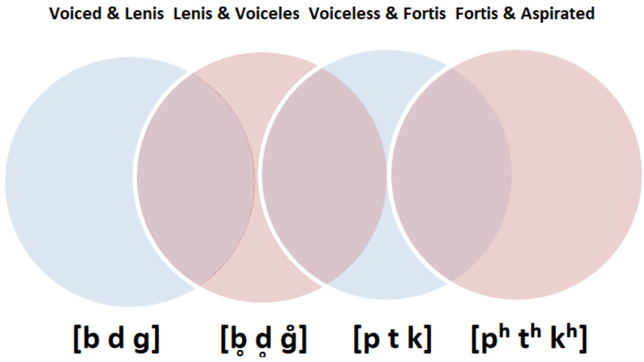

Figure 3: articulatory overlapping in the phonetic realisations of / p t k & b d g/ in Spanish (in blue) & German (in red) in utterance-initial position.

As can be seen in figure 3, Spanish and German stops are not identical in this position; however, there is some overlap. Spanish [b d g] share with German [b̥ d g̊] that both are lenis, but differ in the former being voiced and the latter voiceless; German [b̥ d g̊] and Spanish [p t k] are different in being lenis and fortis, respectively, but have in common that both are voiceless; finally, Spanish [p t k] and German [p^h t^h k^h] differ in that only the latter is aspirated, but both are fortis and voiceless (Kohler. 1981a, compares French and German stops in very similar terms).

There is, to my knowledge, no investigation regarding the perceptual overlap of these sounds in Spanish and German, but both anecdotic evidence [6] and De Villa's *Gramática de la lengua alemana dividida en tres partes* (1792) corroborate that German [b̥ d g̊] are easily confounded with Spanish [p t k]. The author, a phonetically naive Spanish speaker, signals that German /b d g/ sound as "strong" as Spanish /p t k/ owing to the "manly accent" and the "vigorous modulation" typical from German (De Villa, 1792: 23-24).

Acoustic differences in intervocalic position are also considerable. Whereas Spanish /b d g/ are produced as approximants, German makes use of passive voicing. Similarly, German /p t k/ are generally produced with aspiration and never fully voiced, whilst in Spanish aspiration is never present and voicing in these consonants is much more pervasive in frequency and quantity than in German; furthermore, even lenition to approximant has been documented for Spanish /p t k/.

[6] When teaching my German students to pronounce Spanish stops, I always ask them to record themselves pronouncing the German word *bellen* [b̥] 'to bark', send the recoding to several Spanish speakers with no knowledge of German, and ask them to write down the 'Spanish' word they hear. Most speakers claim to hear the Spanish word *pelen* 'peel!', i.e. with [p], but not unusually some report to hear *velen* 'hold a vigil!', i.e. with [b].

2.1.3 Fricatives

In fricative sounds, “turbulences are generated by forcing air through a narrow constriction somewhere in the vocal tract” and, in some cases, “additional turbulences are generated when an airstream breaks against an obstacle in its way, such as the teeth” (Baart 2010: 77). That marks a crucial difference with stops, whose production implies a momentary complete closure, and with taps and trills, which can be seen as very rapid occlusions. In turn, Ladefoged & Maddieson (1996: 137) notes that fricative sounds are very complex sounds, since “a variation of one millimetre in the position of the target for the crucial part of the vocal tract makes a great deal of difference”.

Acoustically, fricative sounds can be very easily distinguished from vowels or stops because of their turbulent noise. Stops are identified by their closure which can be visually appreciated. In turn, vowels have regular pulses reflected on the spectrogram, whereas fricatives form a very irregular image. There is, however, some kind or regularity within this apparently chaotic picture. Maximal intensity is achieved at different frequencies for each fricative (which is reflected in different patterns of darker and lighter areas on the spectrogram); besides, both global intensity and the intensity peak give important information to distinguish fricatives.

Nonetheless, Ladefoged & Maddieson (1996: 137) warns us that “the acoustic structure of fricatives seems to vary widely from individual to individual, but this really reflects only the unfortunate fact that we do not yet know what it is that we ought to be describing”. They propose, however, overall intensity, frequency of the lower cut-off point in the spectrum, and something corresponding to the centre of gravity and dispersion of the spectral components as good candidates of acoustic parameters to investigate fricatives. Apart from our relative lack of knowledge about what is relevant in the production of fricatives, researchers must face the fact that coarticulation individual physiological characteristics heavily affect the acoustic characteristics of the fricatives, making so inter-study comparisons problematic.

The centre of gravity and the dispersion of the spectral components have been tried to be put into numbers by means of a statistical approach calculation known as the four spectral moments. In Jongman et al. (2000), a comprehensive description thereof is offered. The first moment is the mean (also referred to as Centre of Gravity, henceforth COG); the variance or standard deviation (SD) of the mean is the second one, skewness represents the third moment, and, finally, kurtosis is the fourth one. Each of these spectral moments provide different types of useful information.

COG has been found to provide relatively reliable cues for fricative discrimination; Gordon et al. (2002). The authors speak of a tendency for more front tongue articulations to have higher gravity centre values, but also signal several exceptions (e.g. [f]). The SD of the COG reflects the range of the different energy concentrations; thus, a small SD reflects a rather flat shape, but does not tell anything about the frequencies at which the energy is concentrated. Skewness complements these measures by indicating the direction of the asymmetry of the distribution. A zero value indicates a symmetrical distribution around the mean; when positive, it means that there is a concentration of energy in the lower frequencies, whilst, when negative, it indicates a predominance of energy in the higher frequencies. Finally, kurtosis indicates how peaked the distribution is. Negative values are associated with a relatively flat distribution, whereas positive values with spectra with clearly defined peaks. Because of the heavy articulatory effects of adjacent sounds, only the central part of the fricatives is considered for the calculus of the spectral moments (e.g. the central 50%, as in Cicres & Blecua, 2015).

Apart from the spectral moments, other measurements are also frequently reported. One of them is duration, which according to You (1979), as cited in Alwan et al. (2011), varies with place of articulation. It also serves to distinguish sibilants from non-sibilants, being [ʃ ʒ s z] longer than [f v θ ð]. Additionally, the voiced elements of each series present shorter noise durations than their voiceless counterparts. This has been consistently and cross-linguistically attested: Behrens & Blumstein, 1988 (for English); Al-Khairy, 2005: 57 (for Arabic); and Nirgianaki, 2014 (for Greek); it also goes in line with what has been observed for stops. Nonetheless, duration is overall a poor discriminatory cue for fricatives. For English, Behrens & Blumstein (1988) found no difference between [ʃ] and [s], and only a trend for [θ] being shorter than [f]. Conversely, [θ] was slightly longer than [f] in a study on Arabic, although not significantly (Al-Khairy, 2005: 56). Finally, in a cross-linguistic study, duration has been reported to be a poor discriminator for fricatives (Gordon et al., 2002).

A further acoustic measurement also frequently provided is amplitude. In Jongman et al. (2000), both normalised and relative amplitude values are given. Amplitude has been shown to be able to distinguish between sibilants and non-sibilants (Behrens & Blumstein, 1988); the difference is around 10-15 dB in favour of the sibilants. Besides, voiceless fricatives have been found to present greater amplitude than voiced ones (Al-Khairy, 2005: 43), which is in accordance with general intensity differences between voiced and voiceless stops (but see Nirgianaki, 2014, reporting the opposite for Greek fricatives).

Finally, the frequency at which the highest spectral peak takes place is also frequently used in acoustic descriptions of fricatives, for example, Żygis et al. (2015), Jongman et al. (2000), or Martínez Celdrán ([2]2007: 68) for Spanish.

	Frequency beginning	**Frequency at max. intensity**	**Intensity peak**	**Global intensity**
[f]	2000 Hz	5000 Hz	4 dB	7 dB
[θ]	3000 Hz	5550 Hz	13 dB	9 dB
[s]	3000 Hz	3680 Hz	26 dB	24 dB
[x]	1000 Hz	3700 Hz	20 dB	14 dB

Table 18: approximate frequencies for Spanish fricatives; extracted from Martínez Celdrán ([2]2007: 68).

2.1.3.1 Spanish fricatives

Both the number of fricative phonemes and their phonetic realisations vary across dialects. In Central and Northern Peninsular Spanish, the variety used by the group of monolinguals of this study, it is traditionally assumed that there are five fricative phonemes, /f s x ʝ θ/ (but see later in this section for /ʝ/ for a discussion on the actual mode of articulation), whereas the rest of the Spanish-speaking world shares the same phoneme inventory (with important articulatory variation that will be covered in what follows) except for the phoneme /θ/ (only present in Spain).

2.1.3.1.1 Voiceless labiodental fricative [f]

In Ladefoged & Maddieson (1996: 173-177), a discussion on the literature about the acoustic properties of [f] is provided. The authors signal that [f] and [θ] are acoustically very similar. They show that the spectrum of [f] is mostly flat, which can also be observed in Barreiro (1999). Its maximum intensity is reached at a frequency of around 5000 Hz, and 2000 Hz is the frequency at which the sound usually begins (Martínez Celdrán, [2]2007: 68). Quilis's (1981: 229) also remarks the low intensity of [f] and Borzone de Manrique & Massone (1981) provide values for Argentinean Spanish that vary with vowel-context from 2150 Hz to 1466 Hz. Lastly, in Cicres (2011), the values for the four spectral moments are reported and it becomes patent that the COG varies extensively among speakers.

The voiced counterpart of /f/ is /v/, unlike in German, only exists in Spanish as an allophone in words like *A**f**ganistán* 'Afghanistan' (Hualde, 2005: 51). This contextual voicing of /f/ is not constant across speakers and is very marginal because /f/ very rarely appears in coda position. Lastly, intervocalic /f/ may undergo partial or total voicing.

2.1.3.1.2 Voiceless interdental fricative /θ/

This phoneme divides sharply Standard peninsular Spanish from the rest of varieties, i.e. American varieties, Canarian Spanish, and most forms of Andalusian. It is present in a multitude of Spanish words; those written <z> and those written <ci> and <ce>, which are pronounced by most native speakers as [s], but in central and northern parts of Spain as [θ].

Articulatorily, it involves the placement of the tongue between the inferior and superior teeth. Acoustically, it is characterised by presenting an energy concentration around 5000 Hz at the beginning of the sound, whereas 6178 Hz is the frequency reported at the maximum intensity peak in Martínez Celdrán ([2]2003: 84). Quilis (1981: 229) also points out that the frequencies for this sound are enormously vowel-sensitive: in the sequence [θa] it can reach 6400 Hz, whilst in [θu] it can have moments of low very low frequencies in comparison (2400 Hz). According to this author, this can be accounted for by the volume increase in the back cavity as a result of labialisation. Jongman et al. (1998) report an even higher spectral peak location at 7503 Hz for English [θ] and report a significant gender effect in their data, which may explain the differences with the Spanish studies, but differences in tongue protrusion are not to be discarded. These authors also report a mean duration of 126 ms, and an intensity of 58.7 dB, which is a reduction of 18 dB in comparison with next vowel. An almost identical intensity difference with the next vowel is also found in Sorianello (2003) for Florentine Italian. Her mean frequency, 5317 Hz, is also in accordance with the above data from Martínez Celdrán. Heinz & Stevens (1961) found in a perception study, that a difference in intensity relative to the vowel of −15 and −25 dB was necessary in order to perceive both [f] and [θ]. However, see Alwan et al. (2011) for a summary of (slightly) divergent opinions in other works.

In a more recent study, Jongman (2000) reports a spectral mean frequency of 5137 Hz for averaged items of [θ] and its voiced counterpart, i.e. [ð]. For Spanish, the values reported in Cicres (2011) present extreme variation, ranging from 4542 Hz in one speaker to 7624 Hz in another. Noise amplitude is 54.7 dB, which represents a 21.9 dB difference with that of the next vowel, again in line with previous studies. As for duration, a mean of 163 ms is reported.

It is also worth signalling that intervocalically or after a voiced sound this sound is, at least in some part of southern and central Castilian, frequently voiced (Torreblanca, 1986).

2.1.3.1.3 Voiceless alveolar fricative /s/

Native speakers are typically not aware of the fact that most speakers from Spain and America pronounce /s/ differently. The differences have been described, among many others, in Martínez Celdrán (^{2}2007: 68), who highlights that the typical Castilian realisation is apical, whereas a predorsal one is most frequently found in Andalusia, the Canary Islands, and in American varieties. According to him, the apical realisation is characterised by having greater intensity than the predorsal one; besides, their intensity peaks begin at different frequencies; at 3000 Hz for the former, at 4000 Hz for the latter. Similar findings are reported in Martínez Celdrán & Fernández Planas (^{2}2013: 110), who offer an analysis of both an apical and laminal realisation in which apical realisations were 11 dB more intense than laminal ones. Besides, the first peak appears more intensely and at frequencies that are quite lower in comparison (4622 Hz in the apical vs 6230 Hz in the laminal). Finally, noise concentrations begin at around 3000 Hz for the apical realisation and at 5000 Hz for the laminal one.

Quilis (1981: 234) highlights the large vowel-dependent variation and provides a spectrogram (1981: 238) from a male Colombian speaker uttering *plaza* [plasa] ‘square’, in which frequencies begin at 4212 Hz, not too far from the 5000 Hz mentioned in Martínez Celdrán for the laminal realisation. Likewise, Borzone de Manrique & Massone (1981) analysed data of four Argentinean speakers and the frequencies were also higher than in the case of Spaniards. The authors also mention large interspeaker variation and a heavy effect of vowel context. On the contrary, the spectrograms of Spaniards provided by Quilis totally coincide with Martínez Celdrán in presenting concentrations of energy roughly at 3000 Hz.

The spectral moments of [s] in Spanish are described in Cicres (2011). For the COG there is considerable variation, ranging from 4800 to 5900 Hz approximately. For Argentinean Spanish, i.e., the values are very different, ranging from 1700 to 2900 Hz among the six speakers investigated in Univaso et al. (2014).

Finally, it is worth noting that voiced realisations of /s/ occur with greater frequency than those of [θ] or the voiceless stops (Torreblanca, 1986). In Torreira & Ernestus (2012), a third of their studied cases presented total voicing.

2.1.3.1.4 Voiced palatal approximant /ʝ̞/

Following the Spanish tradition, this sound has been included among fricatives, but as the title of this subsection reflects, it is most of the times an approximant and, consequently, will be excluded from the phonetic analyses. In order to support this decision, this sound has, nonetheless, not been excluded from this literature review.

Aguilar's (1997: 88) evidence is conclusive: 88.75% of /ʝ̞/ tokens were approximants, whereas only 11.25% fricatives. Martínez Celdrán & Fernández Planas ([2]2013: 58) share this view and Hualde (2005: 165) mentions "a voiced palatal weak fricative or approximant consonant" as the typical sound in Standard Castilian. Further evidence comes from Martínez Celdrán (2015), who measured zero-crossings and concluded that /ʝ̞/ is as approximant as any of the other sounds that belong to this category in Spanish, i.e. [β̞ ð̞ ɣ̞]. Zero-crossings-rate has been proved to be a good parameter to put into numbers the difference between fricatives and approximants, since what is measured is the number of times that the speech signal changes from negative to positive and vice-verse, i.e. the higher this parameter, the more we can associate it to a fricative, as the typical turbulences of fricatives are characterised for crossing the zero-line multiple times.

Finally, it must be noted that in Argentina, this phoneme is always fricative, either voiceless [ʃ] or voiced [ʒ] (Chang, 2008) and is produced in the post-alveolar region.

2.1.3.1.5 Voiceless velar fricative /x/

In this subsection, the acoustic characteristics of what is considered the standard realisation (i.e.[x]) of this phoneme will be first described. Then, a description of the acoustic properties of its main allophones will be provided.

[x] is globally more intense than [f] and [θ], thus, second in intensity among Spanish fricatives, only 5 dB less than [s] (Martínez Celdrán & Fernández Planas, [2]2013: 107). These authors also report its intensity peak around 1770 Hz, but close to 4000 Hz there is also a second peak, and a third one at 6000 Hz. In turn, the values reported in Borzone de Manrique & Massone (1981) for /x/ vary considerably, from 2950 to 9000 Hz, depending on the vocalic context. The duration reported in their study is 196 ms for unstressed position, and, surprisingly, considerably shorter in stressed syllables 147 ms.

Uvular realisations, [χ], are characteristic of northern and central Peninsular Spanish (Hualde, 2005: 154). Martínez Celdrán & Fernández Planas's articulatory data ([2]2013: 111-112) show that the uvular realisation takes place in contact with /a/, /o/, and /u/. Martínez Celdrán & Fernández Planas also compare the peaks of the uvular realisation [χ] and the velar one [x] (2013: 112); for [χ] the first peak appears around 960 Hz, whilst in their second example of [x] at 1600 Hz. On the contrary, the second and third peaks coincide at around 3900 Hz and 6000 Hz, respectively (the uvular presents a much more prominent peak, though).

Conversely, in Andalusia and the Canary Islands, a glottal fricative [h] is typically found, which may also undergo partial or total voicing when intervocalic [ɦ]. [h] also predominates in the Caribbean, in Central American and Colombian varieties, whilst [x] in Mexico, Peru, Chile, and Argentina (Hualde, 2005: 155). In Chile there is more fronting before [e] and [i] than typical in the rest of dialects; indeed, Hualde and many others have noted that it is possible to talk about allophonic variation between [x] with back vowels and a voiceless palatal fricative [ç] before front vowels. The Chilean [ç]-realisation of /x/ is described in Quilis (1981: 244), who reports a mean frequency of 2600 Hz and 2400 for the beginning when in contact with [e]; whilst with [i] the mean frequency is 2900 Hz.

Finally, as noted in Martínez Celdrán & Fernández Planas ([2]2013: 117-118), there are references of a trilled pronunciation of /x/. The authors note that this pronunciation is not analogous to that of other rhotics, but they admit that vertical striations are frequently observable on the spectrograms. Horizontal bands are also recognizable in their example, but they are not comparable to the formants of harmonic sounds in view of the authors. These authors also note the frequency of this variant of /x/, but do not propose any symbol for its transcription.

Despite its wide occurrence, this sound is largely ignored in the literature on Spanish phonetics except for some acoustic remarks giving in passing. Apart from the mention in Martínez Celdrán & Fernández Planas, only five more references are known to us.

In his famous *Manual*, Navarro Tomás ([25]1991: 142) comments on the pronunciation of /x/ that in "vigorous pronunciation, *j* easily passes from fricative to vibrant" (translation mine), i.e. the sound presents both friction and a trilled part. Once again, this author pioneered in the field of Spanish phonetics by noticing a sound that, 100 years after the first edition of this *Manual,* is still generally ignored. Likewise, Gili Gaya (1958: 139) refers to this sound just in passing. With almost identical words to his mentor, he expresses that "in strong and emphatic pronunciation, Spanish [x] becomes vibrant" (translation mine). He also adds a note comparing the allophones of Spanish and German and states that this sound is inexistent in German.

Similarly, Quilis ([2]1999: 270) observes in a spectrogram produced by a speaker from Madrid uttering *ca**j**a* 'box' that there are some vertical striations which correspond to small vibrations produced by the interaction of the velar area and the postdorsum at the moment of constriction. Lastly, in D'Introno et al. ([2]2010: 313) just a very short mention is made: “in tense and emphatic pronunciation becomes a vibrant velar”, which is an inaccurate description, since both friction and trilling occur simultaneously.

The only other reference to this sound known to me is Kohler (online) in a very short introduction on Castilian Spanish published on the website of the influential former Institute of Phonetics and Digital Speech Processing (Christian-Albrechts-University zu Kiel). He includes the symbols [χ͡ʀ̥] and [x͡ʀ̥]; the former representing /x/ in ***j**unio* ‘June’, and the latter in ***j**azmín* ‘jasmine’ (by clicking on the word, it is possible to listen to the file and download it). There is no mention at all along the very short text about this interesting sound, but we are told that the female speaker comes from Madrid.

According to the German phonetician (private correspondence, 2017), [χ͡ʀ̥] symbols a double articulation, which is voiceless and composed of a uvular fricative and a uvular vibrant (i.e. a trill). The friction appears simultaneously to the constriction created between tongue and uvula. The author also kindly shared with me that he guesses that /x/ in combination with [a] is most prone to trigger trilling alongside with the normal friction. The rationale behind this idea is that in [a] the tongue gets closer to the uvula and, therefore, it is easier to be set into motion by means of the airstream being expelled.

Both Klaus Kohler and I agreed on identifying a phonetic realisation of [χ͡ʀ̥] in figure 5, to which I will refer henceforth as a voiceless uvular trilled fricative. The reason that motivates such a terminology is that I agree with Martínez Celdrán & Fernández Planas in that the acoustic characteristics of this sound resemble more a fricative than a trill.

As described in Abercrombie (1967: 49), “if there is a close approximation of the articulators while a trill is being made, the result is a fricative-trill, in which the noise of friction, as well as the noise of vibration, can be heard. [...] Segments of this type are somewhat uncommon.” Such description can be confirmed by simply producing a sustained uvular trill and elevating the tongue slowly; before the sound becomes a uvular fricative, there is an intermediate step in which both friction and trilling can be heard. Alternatively, one can produce a sustained uvular fricative and lower the tongue slightly, before it becomes a trill there will also be a moment in which both friction and trilling can be heard.

Both Abercrombie (1967: 49), Šimáčková et al. (2012), and Wells (2014: 192) refer to a Czech sound that also combines friction with trilling: [r̝] (figure 6). This sound, however, is alveolar and voiced. Šimáčková et al. (2012) describe it as “a period of friction interrupted at the beginning by a contact or contacts created by a retracted apico-alveolar gesture”. The IPA notation for this sound uses the diacritic for ‘raised’ applied to the correspondent trill symbol (Wells notes that until the 1989 Kiel IPA convention there was a specific symbol for this sound). Following this notation, the Spanish sound could be transcribed as [ʀ̝̊], i.e. the base of the symbol is a uvular trill which is then combined with the diacritics for both voiceless and raised. The use of [ʀ̝̊] would be desirable so that there is a coherence between the representation of the Czech alveolar fricative trill and the Spanish uvular fricative trill;

however, given that both auditorily and acoustically the Spanish sound seems to normally present a stronger fricative component, the use of proposed by Kohler [χ͡ʀ̥] seems more appropriate to me.

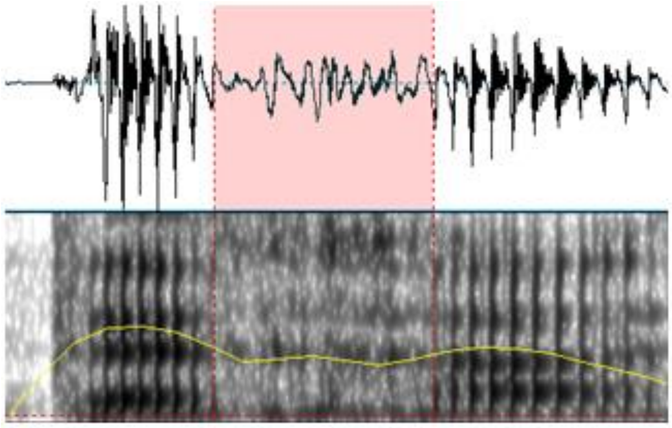

Figure 4*:* male speaker from Madrid uttering the word *lentejas* ‘lentils’ with [χ͡ʀ̥]; in the image only *-teja*.

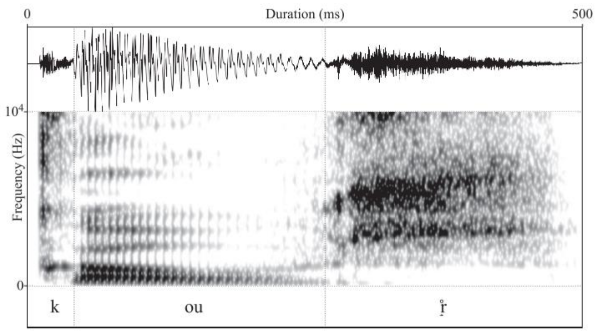

Figure 5: Czech [r̝], taken from Šimáčková et al. (2012).

Other than in Spanish, sounds that, according to the descriptions here reviewed, could possibly also be transcribed with [χ͡ʀ̥] (or [ʀ̝̊]) have also been found in Arabic, Hebrew, Wolof, and Dutch.

Ladefoged & Maddieson (1996: 167) employ the symbol [ʁ̥] to denote a “voiceless uvular fricative trill” in Wolof, which does not seem to be very accurate, since the symbol and the diacritic only represent a devoiced uvular fricative, i.e. the trilled part is ignored. Similarly, Thelwall & Sa’Addedin (1999: 51-54) indicate on their description of Arabic for the Handbook of the International Phonetic Association that [x] “is accompanied by a uvular trill”. In turn, Laufer (1999: 96-99) notes that the voiceless uvular fricative is usually pronounced as a voiceless uvular fricative trill in Hebrew.

Finally, Heijmans & Gussenhoven (1998) and Gussenhoven & Aarts (1999), commenting on southern dialects in The Netherlands, signal that “[ʀ] is a uvular or pre-uvular trill with a fricative component, the latter element being particularly prominent in the coda, where the consonant is partially devoiced”. This sound is treated in detail in Sebregts (2014: 64), who transcribes it by means of [ʀ̝], i.e. as a uvular trill plus the diacritic for raised, which is in line with the notation for the alveolar trill with friction in Czech. The author offers an example of this sound (see figure 7) and notes the following:

> The uvular fricative trill is characterised by a repetitive pattern similar to that of the sonorant trills, but with a higher trill frequency, a less clear formant structure, and the presence of noise (aperiodicity, clearly visible in the waveform). The formant structures of both the uvular trill and uvular fricative trill display a relatively high F3. Vocal fold vibration is generally absent throughout the fricative trill's duration.

The similarity between the Spanish example in figure 5 and the Dutch one in figure 7 is patent.

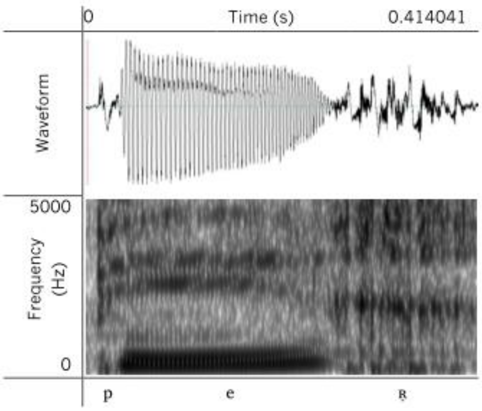

Figure 6: uvular fricative trill in the Dutch item 'peer'; taken from Sebregts (2014: 64).

As can be seen, the sounds in Ladefoged & Maddieson (1996: 167), Thelwall & Sa'Addedin (1999: 51-54), and Laufer (1999: 96-99) are described as fricatives with the special characteristic of presenting a trilled part, i.e. they are tacitly considered as more fricatives than trills, exactly as has been noted for the Spanish sound (Martínez Celdrán & Fernández Planas ([2]2013: 117-118). On the contrary, Heijmans & Gussenhoven (1998), Gussenhoven & Aarts, and Sebregts (2014: 64) assume that the sound they are describing is a trill with a fricative component. Likewise, as noted before, the mixed alveolar Czech sound commonly represented as [r̝] is also treated as a trill with friction. Whether these sounds present actual phonetic differences, i.e. whether there is less friction and more trilling in the Dutch sound than in the Spanish, Wolof, Arabic, and Hebrew one, is yet to be studied. What is clear is that whereas in Dutch this sound has emerged after raising the articulator when producing the uvular trill, in Arabic, Hebrew, and Spanish the original sound was a uvular fricative in which the tongue has been slightly lowered, triggering so trilling.

The sociophonetics of this sound need to be investigated, but as signalled in the short mentions here reviewed, its occurrence takes places with great frequency in the regions where uvular pronunciations exist; indeed, it appears even in formal situations[7].

2.1.3.2 German fricatives

This sound class has much less diatopic variation in German than in Spanish, but, contrary to Spanish, presents phonemic contrasts between homorganic fricatives by means of voicing and tenseness. These

[7] Very clear examples of this sound are constantly found in the singer of the group *Rulo y la Contrabanda*: e.g.: https://www.youtube.com/watch?v=8BI-9SNV-xc. A less emphatic pronunciation, and consequently in which vibrations are not that obvious, is available in this short speech produced by journalist Gemma Nierga, for example in seconds 18-19 or 37 (*cae mejor* and *mujer*): https://www.youtube.com/watch?v=WVSQIe5P2J0.

phonemic contrasts, however, present wide context-dependent variation. In utterance-initial position, voiceless fricative realisations of phonologically voiced fricatives are not uncommon for some speakers (Jessen 1998: 88, for his own data, and 1998: 65-67, for a literature review with data in the same direction). On the contrary, the voicing in word-initial intervocalic fricatives is consistent for the lax consonants throughout most part of the segment (Jessen 1998: 86). In both contexts, however, there is a consistent difference in duration across; fortis fricatives are longer than the lenis. Finally, these phonemes become neutralised in coda position (Beckman et al., 2009).

2.1.3.2.1 Voiceless labiodental fricative /f/

C. Hall (^{2}2003: 38) describes the production of this sound as an action in which the lower lip and the upper front teeth (incisors) are brought together to form a narrowing, where turbulence will be created then the airstream passes rapidly. Russ (2010: 71) notes that [f] is fortis and, thus, longer than [v], "especially medially between vowels". The data in both Pape & Jesus (2015) and Hamann & Sennema (2005) support this claim (172 ms for the voiceless and 102 for the voiced fricative). Lastly, according to Niebuhr (2012), its COG takes place around 5750 and 5450 Hz. Conversely, in Lorenzen (2004), it appears around 3600 Hz, and in Hamman & Sennema (2005) at 4808 Hz.

2.1.3.2.2 Voiced labiodental fricative /v/

It is the voiced counterpart of /f/ and its spelling is typically <w> but also <v> in some relatively recent loan-words, such as *privat* "private" or *Klavier* "piano". C. Hall (^{2}2003: 38) notes that some speakers have a bilabial fricative, which is very similar to the approximant [β̞] present in Spanish, but, as noted in Russ (2010: 73), this bilabial pronunciation is to be found only in southern Germany, Austria, and Switzerland.

Because of being lenis, it is shorter than [f] (Pape & Jesus, 2015; and Hamman & Sennema, 2005). The latter authors, however, note that /v/ is frequently produced as an approximant in initial position [ʋ], hence the striking contrast in terms of COG between /f/ and /v/: 4808 Hz for the former and 1735 Hz for the latter.

2.1.3.2.3 Voiceless alveolar fricative /s/

An articulatory description is provided in Russ (2010: 73):

> The active articulator is the tongue, which approaches the upper alveolar ridge. The blade of the tongue narrows the opening between the alveolar ridge and itself. The tip (apex) of the tongue is usually turned down. The back (dorsum) of the tongue presses against the side teeth and creates a groove over which the air-stream is forced out through the gap between the alveolar ridge and the blade of the tongue. The vocal cords are usually not vibrating and the nasal cavity is sealed off by the raising of the velum.

As can be seen, according to this author, the most typical realisation of /s/ is pre-dorsal, which means that the acoustic parameters for this sound should pattern more those of Canarian, Andalusian, and American speakers than those of the speakers from central and northern Spain. However, Kohler ([2]1995: 161) notes that German /s/ is apical.

As can be inferred from the figures in Niebuhr (2012), [s] typically presents its gravity centre between 8000 and 8300 Hz, whereas in Jannedy & Weirich from around 5000 Hz to, most typically, 7000-8000 Hz.

2.1.3.2.4 Voiced alveolar fricative /z/

Russ (2010: 74) indicates that the articulation of [z] equals that of [s] except for the vibration of the vocal cords. It is noted, though, that in initial position before a vowel, there can be a delay in the voicing, which may start halfway through the sound. According to Russ, there is some dialect variation; "in southern Germany, Austria, and Switzerland [z] can be voiceless, or at least fortis". In the north, however, because of being lenis, it is expected to be shorter than [s].

Apart from the data on duration reported in Pape & Jesus (2015); no other acoustic data are known to me specifically referring to German [z]. Therefore, the spectral moments reported in Jongman et al. (2000) for English [z] & [s] (without distinction between both sounds) are here taken as a reference: 6133 Hz for the spectral mean, 2.92 MHz (variance), and a skewness and a kurtosis of -0.229 and 2.36, respectively.

2.1.3.2.5 Voiceless alveolar post-alveolar fricative /ʃ/

Russ (2010: 74) describes the articulation of this sound as follows:

> The blade of the tongue forms a constriction (narrowing) between itself and the front part of the hard palate. This place of articulation is also labelled prepalatal or alveo-palatal. The tip of the tongue may be facing up or down. The back (dorsum) of the tongue is raised and the sides rest again on the side teeth. The air-stream is forced rapidly along a wide groove, wider than that for [s], and out through the gap created between the blade of the tongue and the front part of the hard palate. The cords do not vibrate [...]. The lips are often rounded and fronted, especially before front rounded vowels.

Normally, <sch> represents this sound, but in the groups <st> and <sp> the <s> is also pronounced as [ʃ].

Acoustically, it has been reported to present its COG at some point between 6250 and 5500 Hz (Niebuhr, 2012), at between 3000 and 5000 Hz (Jannedy & Weirich, 2016), and, most typically, between 4000 and 6000 Hz in Jannedy & Weirich (2017).

2.1.3.2.6 Voiced post-alveolar fricative /ʒ/

The only difference in production with [ʃ] is that it is voiced. It is a very marginal sound in German; it typically appears only in words of French origin with the spelling <g>, e.g. *Genie* “genius”.

Unfortunately, it is usually left aside in acoustic studies on German fricatives owing to its marginal status within German phonological system, and the only acoustic reference known to me is Pape & Jesus (2015), which confirms that, as the voiced counterpart of [ʃ], it is typically shorter. Lastly, it is worth mentioning that word initially can also be partially or totally devoiced, especially in colloquial speech, Russ (2010: 76), merging thus with [ʃ].

2.1.3.2.7 Voiced palatal approximant /j/

[j], used in German words written <j> (e.g. ***j**ung* ‘young’), is described on the IPA chart as an approximant; however, it is frequent to find this symbol described among fricatives in the German tradition. For instance, Russ (2010: 78) presents the fricative realisation as the default one but adds that this sound “sometimes can be regarded as approximant”. Yet, he employs the IPA symbol for the approximant, i.e. [j], instead of the corresponding fricative [ʝ], which would have been more coherent with his claim. He also notes that it is similar to the initial sound in English *yes*, *yet*, but with more friction. In English, both words are transcribed with [j] and, consequently, considered to be approximants.

In a similar vein, C. Hall ([2]2003: 48) notes that “sometimes” its realisation is so reduced that the sound is not a fricative, but an approximant, and also compares it with the English approximant [j] and states that this sound causes no problem for English speakers, as the same sound than in *yes* or *yonder* can be used. Implicitly, what C. Hall is saying is that the approximant realisation can be applied everywhere and consistently (not just “sometimes”). On the contrary, Kohler Kohler ([2]1995: 156) directly claims that this sound is typically an approximant.

Resembling the situation described for Spanish /ʝ̞/, this sound alternates between a fricative and approximant realisation, but the approximant realisation is most common. Therefore, this phoneme will also be excluded from this investigation.

To conclude, it is worth briefly commenting on a discrepancy that the reader will surely have noticed. Whilst in Spanish the voiced palatal approximant is transcribed [ʝ̞], in German the symbol [j] is used. Both uses are consistent with the IPA prescriptions. When the ‘lowered’ diacritic is attached to a fricative symbol, the result is an approximant sound. In this regard, the Spanish tradition is consistent with the use of [β̞ ð̞ ɣ̞]. However, given the current state of the IPA chart, the use of [j] is also legitimate for German /j/ when the sound is considered an approximant, e.g. Kohler ([2]1995: 156). This discrepancy has further implications, since the glide present in Spanish words like ***ci**elo* ‘sky’ is sometimes transcribed as [j], but since neither these approximant phonemes nor glides will be here investigated, no more comments are necessary.

2.1.3.2.8 Voiceless fricatives velar /x/

This phoneme presents context-triggered allophony. According to Hakkarainen (1995: 76-78) and C. Hall ([2]2003: 42), there are only two allophones: the voiceless palatal fricative [ç] and the voiceless velar fricative [x]. Kohler ([2]1995: 160-161), however, distinguishes three allophones, the two just mentioned plus a voiceless uvular fricative [χ]. According to him, the palatal allophone appears after front vowels and diphthongs with a front-vowel as an off-glide, as well as after the consonants /l r n/; [χ] appears after [a(ː)] and [ɔ]; finally, [x] in the rest of the cases, i.e. after close and mid-close back vowels[8], as well as diphthongs ending in either of them. Some of his examples are [ç] *sie**ch*** 'infirm', *Dä**ch**er* 'roofs', *hö**ch**st* 'most'; [χ] *bra**ch*** 'broke', *do**ch*** ≈ 'certainly'; and [x] *Wu**ch**t* 'force', *au**ch*** 'also', *ho**ch*** 'high'.

It is also important to highlight, that this allophony is completely context-based; thus, when a word with [x] is derived, its pronunciation changes *Bu**ch*** [x] 'book' vs *Bü**ch**er* [ç] 'books', C. Hall ([2]2003: 45). This author also notes that, exceptionally, all words derived with the diminutive ending *-chen* are always pronounced with [ç], irrespective of the preceding vowel (*Kuh**ch**en* [ç] 'little cow', vs *Ku**ch**en* [x] 'cake').

It is also frequent that /x/ is subject to typical voicing assimilations, thus, *doch* may usually be pronounced with [χ], but in the sequence *doch mal*, partial or total voicing is expected to happen to occur with regularity.

C. Hall ([2]2003: 47) provides information about dialectal variation; according to him, in the south-western extreme of Germany, and throughout Switzerland, [ç] is replaced by [x] in all environments. Additionally, in some central German dialects, "e.g. in the Rhineland, Saarland, Saxony" [ç] is regularly replaced by [ʃ]. Most relevant for this study, however, is the regional variation that affects northern Germany. The author ([2]2003: 47) notes that whereas <g> is pronounced [ç] both in the north and in the south for the ending ***-i**g*, <g> following a consonant is also not infrequently pronounced [ç] in the north; for example, in the local pronunciation for the city of *Hambur**g***, instead of standard [k]. Lastly, he signals that [x] pronunciations occur in the speech of many northern speakers after back vowels (e.g. *Ta**g*** 'day' pronounced [taːx] instead of standard [taːk]).

Acoustically, [ç] has been described in Jannedy & Weirich (2016 and 2017). The COG reported in these works show great variance, ranging from 3000 to 6000 Hz. For [x], Niebuhr (2012) report a COG between 5500 and 5000 Hz. In Jannedy & Weirich (2016), [χ] values between 1500 and 2500 Hz are

[8] "mid-open back vowels" in the original text, however, it is clear that Kohler had a typing mistake and meant mid-close back vowels, i.e. [o], since, in the same excerpt, the mid-open back [ɔ] vowel is explicitly said to trigger a uvular pronunciation.

reported for Niedersachsen, and between 1500 and 4000 Hz in Thüringen. Given that only three females per group were considered and that typically there is considerable interspeaker variation, it cannot be concluded that those differences are diatopic.

2.1.3.2.9 Voiceless glottal fricative /h/

Russ (2010: 85) describes this sound as different to the rest of fricatives. Its production takes place in the glottis, without movement of the vocal folds, and the lips and the tongue are always modified according to the articulation of the following vowel. In (2010: 29), he also states that it is also called a "cavity fricative", because most of the friction is produced there, and "there are as many different positions of the vocal tract for [h] as there are vowels".

Ladefoged ([2]2005: 58) listed [h] among fricatives but warns that "it is not really a fricative as the source of the noise is not air being forced through a narrow gap. Instead, the origin of the sound is the turbulence", and goes on to note that "the resonances of the whole vocal tract will be more prominent, and the sound is more like that of a noisy vowel". Indeed, faint traces of the two first formants are usually visible, as noted by Ladefoged.

Like Ladefoged, not specifically referring to German, Baart (2010: 32) notes that in [h] there is a gradual decrease in amplitude going from the preceding vowel, and then a gradual increase up to the next vowel. Lastly, he also notes that "the wave associated with the voiceless fricative is pretty much random, but someone with a sharp eye may discern some continuing periodicity".

C. Hall ([2]2003: 48) also notes the extreme coarticulatory effects under which [h] takes place. Indeed, he even states that the corresponding vowel with the diacritic for devoiced could perfectly appear in phonetic transcriptions instead of [h] and offers the example [o̥ox] for ***h****och* 'high', which is in accordance with Kohler ([2]1995: 156). Given that there is general consensus that [h] is not really a fricative, it will not be analysed in this research.

2.1.3.3 Summary

As the reader has surely noticed, linguists know much less about fricatives than about other sound classes. This is reflected not only in a comparatively smaller amount of studies for fricatives, but also in the wider set of acoustic measures reported. For example, Spanish fricatives have often been described reporting the frequencies at which the peaks appeared, whereas only Cicres (2011) and Univarso et al. (2014) report the four spectral moments.

Strikingly, there is large variance across studies that investigate the same acoustic parameters, hence the pertinence of bringing back Ladefoged & Maddieson's words (1996: 137): "the acoustic structure of fricatives seems to vary widely from individual to individual, but this really reflects only the unfortunate fact that we do not yet know what it is that we ought to be describing".

It is beyond the scope of this study to assess the validity of the different acoustic measurements here reviewed; instead, it is sought to ensure that the same methodology is applied to both languages so that comparisons between monolinguals and bilinguals are possible. More details on the acoustic measurements used for fricatives will be given in the methodology section.

2.1.4 Rhotics

Phonological classes do not necessarily coincide with phonetic ones (it has already been evidenced in the section for Spanish stops, which most commonly are approximants), but this holds particularly true for rhotics. This term does not reflect any specific manner of articulation; however, its usefulness as a phonological category is undisputable.

Before phonetically describing all possible rhotic realisations, it is desirable to shortly review the terminology for rhotics in the Spanish and German traditions. Among Spanish phoneticians, instead of rhotics, the term *vibrantes* 'vibrants' has generally been preferred and further subdivided into *vibrante simple* [ɾ] and *vibrante múltiple* [r]. Quilis & Fernández ([9]1979: 129), Quilis ([11]2012: 64-65), Gil Fernández (1999: 100), or Hidalgo Navarro & Quilis Merín (2012: 207) used in this way the term vibrants, following the pioneering Spanish phonetician Navarro Tomás ([25]1991: 20).

On the contrary, Hualde, writing in English, uses the term rhotics (2005: 44-45) and signals that in Spanish these consonants are called *vibrantes*. Besides, he explicitly includes "rhotics" when presenting the different manners of articulation in Spanish (Hualde, 2005: 45). There is no explicit explanation for the use of the term rhotics; besides, in the Spanish version (Hualde, 2013) the term *vibrantes* is used.

In Martínez Celdrán & Fernández Planas ([2]2013: 143-160), there is a section called rhotics in which they explicitly address the terminology problem, but in relation to the terms *vibrante simpl*e and *múltiple* rather than to the term rhotics itself. The use of the umbrella term rhotics proves useful in their work as an example of a spectrogram of a rhotic with a fricative realisation in Spanish is provided ([2]2013: 152 & 159). This way they can treat three different ways of articulation under the same section, which, is desirable given the obvious quasi-allophonic distribution or [ɾ] and [r] in Spanish (see later in this section).

In a previous study, Martínez Celdrán ([2]2003: 41) overtly defended the convenience of using the terms *vibrante simple* and *múltiple* given the acoustic and perceptual similarities of both sounds and also noted that nowadays the word *róticos* 'rhotics' is used by many phoneticians to encompass all kinds of articulations.

Summarising, it can be concluded that the Spanish tradition generally favours the use of the term *vibrantes*, and then its consequent subdivision into *simple* and *múltiple*. However, some phoneticians, especially in relatively recent works, have started using the term rhotics, perhaps because recent research, as will be later reviewed, is showing that non-canonical realisations, even with fricative realisations, are much more frequent than previously thought.

In the German tradition, there is a similar problem; there are different phonetic realisations for a single phonemic entity, usually referred to as /r/. The problem lies therein that these phonetic realisations are very different in manner of articulation, which complicates the exact collocation of the phoneme /r/ when the sounds are grouped according to manner of articulation. There are several solutions.

For example, C. Hall ([2]2003: 60) simply includes a section called /r/ along with other sections called nasals, fricatives etc., i.e. he mixes an indication about phoneme status with others that clearly refer to manner of articulation, which is totally equivalent to my use of the term rhotics without a specific meaning about its articulatory nature.

Similarly, Russ (2010: 84) uses a very similar umbrella term, “r-sounds”, anew equivalent to rhotics in this dissertation. Kohler attempts to provide a phonetic description of German phonemes, and when listing the different manners of articulation (1995: 152), he excludes the phonemes /h j r/. For /r/, he notes that it does not make any sense to classify phonetically the phoneme /r/ in view that there is even intraspeaker variability; but he does provide a phonetic characterisation of all its possible realisations (1995: 165).

As can be seen, rhotics are problematic in both languages. Spanish presents a canonical trill and a canonical tap, i.e. two different manners of articulation that coexist with non-canonical variants such as fricative realisations. In German, there are also several phonetic forms for just one rhotic phoneme and phoneticians explicitly reject to choose a prototypical manner of articulation.

Finally, Gabriel et al. (2013: 72) use the term *Vibranten* (in German) but explicitly state that they use it as a generic term for the class of r-sounds. Among all the above-cited possibilities for umbrella terms for /r/-sounds, the term rhotics has been chosen, following Hualde (2005), given its total lack of phonetic indications.

2.1.4.1 Rhotics in Spanish

As mentioned in the introduction to this section, many authors from the Spanish tradition unfortunately still use the terminology *vibrante simple* and *vibrante múltiple*. Such terminology is misleading because it implies that in the *vibrante múltiple* there is always more than one contact, which does not go in line with the newest acoustic data, and it suggests that there are no articulatory differences between both sounds, which is clearly against the existing evidence.

In what follows the distribution of the tap and the trill in Spanish as well as their articulatory and acoustic differences will be described; additionally, an outline of other phonetic realisations will also be provided. The latter two aspects will justify the use of the terms trill and tap instead of *vibrante simple* and *vibrante múltiple*[9].

The complementary distribution of the tap and the trill in Spanish was already described by Navarro Tomás ([25]1991). This distribution is as follows. The tap [ɾ] and the trill [r] contrast in medial position, i.e. it is possible to form different words by exchanging solely these elements: *mi**rr**a* 'myrrh' *vs mi**r**a* 'look!' or 's/he looks', *po**rr**o* 'joint' *vs po**r**o* 'pore', *fo**rr**o* 'lining' vs *fo**r**o* 'forum', *pe**rr**a* 'female dog' vs *pe**r**a* 'pear', *mo**rr**o* 'snout' *vs mo**r**o* 'Moor', etc. Word-initial position is exclusively reserved for the trill, whilst the coda is normally reserved for the tap, but, in emphatic or humoristic use, it is not infrequent to hear a trill. Lastly, as described in Gabriel et al. (2013: 73), a tap will be realised when in contact with another consonant if both consonants are tautosyllabic (*b**r**oma* 'joke', *lad**r**ón* 'thief'), but a trill will occur if both consonants belong to different syllables (*hon**r**a* 'honour', *is**r**aelita* 'Israeli'). This quasi-allophonic distribution is a further argument to describe both sounds together.

Articulatory differences between the tap and the trill

Articulatory, there is solid evidence that both sounds are very different; whereas the tap involves an active tongue movement, the tongue plays a rather passive role in the production of trills. Ladefoged ([3]1993: 169) describes as follows the production of alveolar trills:

> Learning to make a trill involves placing the tongue, very loosely, in exactly the right position so that it will be set in vibration by a current of air. The easiest position seems to be with the tongue just behind the upper front teeth and about one 1 mm away from the alveolar ridge. The jaw should be fairly closed, leaving a space of 5 mm between the front teeth. [...] The problem experienced by most people who fail to make trills is that the blade of the tongue is too stiff.

As can be seen in the author's description, the trill basically involves the placing of the tongue in the right place and with the exact degree of stiffness, and then producing an air torrent that will set the tongue in motion.

Conversely, Ladefoged ([3]1993: 168) defines the tap as a sound caused "by a single contraction of the muscles so that one articulator is *thrown* against another. It is often just a very rapid articulation of a stop". The italics are mine in order to highlight the active role of the tongue and the ballistic nature of the tap in contrast to the relatively passive role of the tongue in trills and its vibratory nature. What is more, he explicitly alerts that "even in the case of a very short trill where there is only a single contact [...], the movement is different from what is sometimes called a tap, or a flap". The possibility of one-contact-trills is again overtly exposed in more recent works (Ladefoged & Maddieson, 1996: 218).

In line with this articulatory definition of the two sounds, Catford (1977: 130) also alerts that "any idea that a trill is a 'rapid series of flaps', or that a flap is just an 'ultrashort trill' is quite wrong".

---

[9] In R.A.E. (2011: 246), for different reasons to the ones here exposed, the terms *vibrante* and *percusiva* are used instead of *vibrante múltiple* and *vibrante simple.*

Corredera (1949, as cited in Martínez Celdrán & Fernández Planas, [2]2013: 145) offers a different definition of the apical trill. In his explanation, a gentle pressure of the apex on the alveolar ridge is needed. The air pressure would break such resistance, but as a consequence of the air expelled, the tongue could recover its position, causing so an increase in air pressure, which in turn would break again the resistance.

Martínez Celdrán & Fernández Planas ([2]2013: 150) argue, on the contrary, that the tongue recovers its position because of the Bernoulli Effect and that the gentle pressure on the alveolar ridge is only needed if we consciously attempt to prolong the trill. In their view, the Bernoulli Effect is crucial to produce trills and they dedicate several pages to a detailed explanation of its role ([2]2013: 147-150); what follows is a very relevant excerpt from page 150:

> No cabe la menor duda de que la producción de la vibrante múltiple aprovecha el efecto Bernoulli. El ápice de la lengua se eleva hasta tomar contacto con los alveolos y ejerce una presión suficiente como para impedir el paso del flujo de aire en un primer movimiento voluntario. La presión del aire espirado va aumentando progresivamente hasta vencer la resistencia del ápice. Éste e se separa entonces dejando una abertura estrecha por la que se desliza el aire a gran velocidad, lo cual causa una disminución de la presión (efecto Bernoulli) y crea una especie de vacío que obliga al ápice a ocuparlo y unirse de nuevo a los alveolos.
>
> 'There is absolutely no doubt that Bernoulli effect is involved in the production of trills. The apex, in a first voluntary movement, is elevated so that it touches the alveolar area, pressing enough so that it the flux of air is impeded. The expired-air pressure increases progressively until the resistance caused by the apex is overcome. The apex then is moved apart, leaving so a narrow passage through which the air slides away at great speed, which causes a decrease in air pressure (Bernoulli effect) and creates a kind of vacuum that forces the apex to occupy it and contact again with the alveolar area.' (translation mine)

In addition, Martínez Celdrán & Fernández Planas ([2]2013: 152) explicitly reject the possibility indicated by Ladefoged of one-contact-trills. According to them, one-contact-trills are incongruent with the mechanisms involved in the Bernoulli Effect.

Furthermore, they also introduce a new element in their description ([2]2013: 143); according to them Spanish rhotics have both a rapid occlusive contact and a very short vocalic element. In intervocalic taps, it usually overlaps with the following vowel, posing so difficulties for a clear segmentation. In trills, there is a vocalic element after each occlusion, although the last one can usually not be appreciated, as it is joined to the next vowel.

Another highly relevant aspect signalled by these authors is that, in view of their electropalatographic data, the trill and the tap in Spanish slightly differ in their location, being the tap alveolar and the trill post-alveolar.

They also mention that adjacent vowels trigger more coarticulatory effects in the tap-production than in the trill, which, as they themselves note, is in line with Recasens & Pallarès (2001) for Catalan. Lastly, they also point out that both sounds share present few contacts on the palatal area, from which can be inferred that the dorsum needs, to a lesser or greater degree, be prevented from elevation.

Additionally, as noted for Catalan in Recasens & Pallarès (1999), but, in all likelihood also for Spanish, a retraction of the post-dorsum is also necessary. In sum, the trill involves a very precise articulation, which is the reason whereby Recasens & Pallarès (1999) think that coarticulatory effects are usually hindered. Namely, they claim that trills are less prone to labialisation than taps. In a similar vein, Henriksen (2014) found that the number of contacts is influenced by the preceding vowel ([u] triggers the smallest number of lingual contacts).

Conversely, the tap is different in nature to the trill, (regardless of the number of lingual contacts of the latter) since it can be described as a ballistic movement. It is a very rapid occlusion similar to that of [t] and [d].

Acoustic differences between taps and trills

Perhaps the only acoustic commonality between taps and trills is that there is a pronounced fall in intensity takes place along both segments (Massone, 1988). Conversely, number of lingual contacts has traditionally been seen as the main difference between both sounds. This aspect was already briefly sketched when reviewing articulatory differences, but, owing to its irremediable influence on duration, will be here discussed in more detail.

Since Navarro Tomás' seminal work, *Manual de Pronunciación Española* ([25]1991, [1]1918), it has been assumed that the number of lingual contacts is crucial to distinguish between trills and taps in Spanish. However, a series of recent studies has provided sufficient ground to at least question such statement and believe that acoustically the difference between trills and taps in Spanish may be maintained even in one single contact trills.

Kouznetsov & Pamies (2008) do not literally state to have found one-contact-trills in Spanish but compare the acoustic properties of 1-contact-trills in Russian with trills in Spanish and conclude that "the established close resemblance between Russian and Spanish trill supports the view that Spanish trill can be produced with only one closure". Henriksen (2014), in an investigation with speakers of León and Ciudad Real (Spain), found trills with different number of contacts and divides his results in: a) trills containing two occlusions (45.2% of the total corpus); b) trills with three or more occlusions (25.6%); c) 1-closure trills (17.8%), which are said to have "a clear occlusion in both the waveform and the spectrogram" and to have "a long period of r-coloured voicing with lowering of the third formant"; and finally, d) 0-closure variants (11.4%), e.g. approximant realisations.

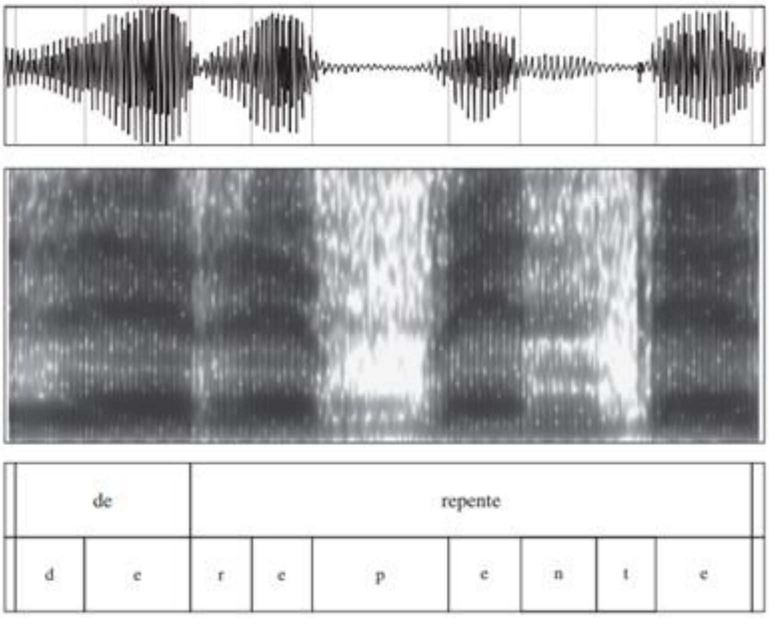

Figure 7*:* one-contact (white vertical bar during /r/) trill; taken from Henriksen (2014).

Bradley & Willis (2012) also report data on several speakers with only one closure for trills in the Mexican Spanish of Veracruz. Lastly, Henriksen & Wilis (2010) also report results on Andalusian Spanish with a very high occurrence of 1-occlusion-trills (44.2% of their corpus) followed by a period of r-colouring, assibilation, or frication. Outside the Spanish-speaking domain, trills have also been reported to be commonly realised with a single contact in, for example, Czech (Šimáčková et al., 2012).

In sum, recent acoustic investigations support the idea that one-occlusion-trills are not only possible, but also a firm reality in several Spanish dialects. This has many implications. The first and most important is whether there is an acoustic base that allows listeners to make a perceptive distinction between a one-contact trill and a tap, or whether in such realisations both sounds become neutralised.

To answer this question, it is of interest to review the acoustic data provided in the previously mentioned works. In Henriksen (2014), the data of 24 speakers of Northern Castilian (León) and Southern Castilian or *Manchego* (Ciudad Real) are provided. As mentioned before, trills with one contact were found in both dialects, but were more frequent in Ciudad Real (24.8%) than in León (11.9%). Trills with three contacts were more frequent in León, whereas phonetic trills produced with no contact were more common in Ciudad Real. Additionally, women tended to produce trills with more occlusions than men in both dialects.

As one could imagine, overall duration generally increases as the number of occlusions increases, but it was also found that one-closure trills lasted longer in León than in Ciudad Real (67 ms vs 51 ms). What is more important to answer our questions is that, as pointed out by the author, both measures are considerably longer than taps.

In a similar vein, Roller (2011) reports an average of 25 ms duration for taps in Ciudad Real, which also discards a phonological merger. Additionally, r-colouring (i.e. approximantisation) is mentioned in Henriksen (2014) as a supplementary means to maintain the tap-trill contrast in peninsular Spanish. Interestingly, women not only produced more lingual contacts in both cities (a pattern repeated in Venezuelan Spanish; Díaz-Campos, 2008), but also more prolonged.

Interestingly, if we move further southwards, to Jerez de la Frontera (Andalusia, Spain; Henriksen & Willis, 2010), the mean rate decreases again; apparently forming a continuum:

Study	Dialect	N° of occlusions
Henriksen / Willis (2010)	Andalusian / Jerez de la Frontera	1.13
Henriksen (2014)	Southern Castilian / Ciudad Real	1.56
Roller (2011)	Southern Castilian / Ciudad Real	1.51
Henriksen (2014)	Northern Castilian / León	2.18

Table 19: mean rate of occlusions for phonemic trills in peninsular Spanish.

As will be later discussed, the results for rhotics in this research with speakers from Madrid and Toledo (3.4.4.2.1) confirms the existence of a continuum in Spain, wherein the number of lingual contacts increases from south to north.

However, there is no such continuum for one-closure trill duration, since Jerez de la Frontera counts with a mean duration of 66 ms for such trills, whereas as above stated it was 67 and 51 for León and Ciudad Real, respectively. In both cases, again, trill duration was much higher than that usually reported for taps.

Other studies have also provided information on formant structure. For instance, Massone (1988) observes that [r] presents successive vibratory movements formed by aperture periods, in which formants can be observed, and closing or silence periods, in which a blank space is appreciated. F1 values are around 500 Hz, F2 ranges between 1200 and 1600, depending on the following vowel. Finally, F3 has a frequency of 2200. Regarding segment duration, she notes that there is a clear effect of speech rate and syllable structure but gives as a reference the values of 118 ms for [r] in CV position and 143 in VCV. Besides, she notes that the aperture periods in her data are 23 ms and the closing ones just 7 ms. As for the taps, she mentions that there is a band in the low frequencies around 500 Hz, and, sometimes, a noise-band is also observable around 2000 Hz. The values for the approximant are slightly different: 450 Hz for F1, whereas F2 varies greatly depending on the vowel. Both sounds last around 22 ms, i.e. considerably less than trills and in accordance to the above-cited studies.

In a study on Canarian Spanish (Almeida & Dorta, 1993), the tap is said to last 36.5 ms and 26.6 ms in stressed and unstressed position, respectively; 40 ms when the realisation is fricative. They also note that these durations are slightly longer than those reported in Quilis (1981): 22 ms and 18.6 ms for stressed and unstressed syllables. It is also worth mentioning that most of the realisations found in their study were approximants; only 18% of their phonemic taps are realised with an occlusion. As for the trill, they also provide separate data for duration depending on the type of realisation of phonemic trills: 96.8 ms and 93.2 ms for stressed and unstressed syllables in the case of actual trills, 61.3 ms and 76.6 for fricative realisations, and 77.1 ms and 57.4 ms in the case of the approximant variant. Interestingly, even when both taps and trills are realised as fricatives, both segments have clearly different durations (the fricative tap had a mean duration of 40 ms). It must be also noted that these data on trills are slightly different from those in Quilis (1981: 292), where, contrary to expected, the unstressed syllable has a longer duration (87.7 ms) than the stressed one (82.5 ms). Both studies, in turn, differ from Massone (1988), whose values for the trill are considerably greater.

In sum, there is a general trend for the phonemic trill and tap to be regularly opposed in terms of duration, regardless of their concrete phonetic realisation. In the different above-cited works from Henriksen and Roller (2011), even when the trill is realised with a single contact, it is still considerably longer; similarly, in Almeida & Dorta, even when both the trill and the tap are both realised as fricatives, the trill is again considerably longer.

Neither tap nor trill variants

Along with the above-described canonical variants, other phonetic realisations may occur. There is evidence thereof dating as back as Navarro Tomás ([25]1991: 116-117), who already mentioned the existence of fricative realisations for /r/ even in the casual speech of educated speakers. More recent studies have provided more evidence that confirms that prescribed trills are not always the norm, for some speakers even a rare occurrence. This applies to both American (Bradley & Willis, 2012; Colantoni, 2006; Díaz-Campos, 2008; Vaquero & Quilis, 1989; Willis & Bradley, 2008) and peninsular dialects (Henriksen & Willis, 2010; Henriksen, 2014; Blecua, 2001).

Apart from fricative realisations, there is also an approximant version of the phonemic trill and tap. Visual examples thereof are commented in Martínez Celdrán & Fernández Planas ([2]2013: 159), and the authors note that:

> El elemento rótico se manifiesta mediante una breve oclusión seguida de un elemento vocálico igualmente muy breve, le sigue un elemento aproximante más el elemento vocálico unido a la vocal siguiente. Por tanto, se trata de un segmento mixto: mitad vibrante, mitad aproximante.
>
> 'The rhotic element is manifested by means of one brief occlusion followed by a vocalic element, very brief as well, then follows an approximant element plus the vocalic element joined to the next vowel. Thus, we are dealing with a mixed segment: half trill, half approximant.' (translation mine)

This description seems to coincide with that of Henriksen (2014) signalling a single occlusion plus an r-coloured part. In any case, what is clear is that all authors who have studied rhotics in Spanish have found many divergent realisations of the canonical trill (with at least two occlusions) and of the canonical tap (produced as a rapid occlusion in the alveolar area). Indeed, sometimes these realisations are even more numerous than their canonical versions. For instance, in Martínez Celdrán ([2]2003: 45), it is claimed that apical taps are normally pronounced as [ɾ̞] approximants.

Finally, in addition to approximant and fricative realisations, it is worth mentioning a possibility that is often ignored: elision. This possibility accounts for 16.75% of all rhotics in Ortiz de Pinedo (2012).

2.1.4.2 Rhotics in German

German rhotics have a single phoneme, normally represented as /r/, which may present multiple realisations and whose distribution is not completely regular and consistent across dialects and speakers. Phonetic realisations may differ from an alveolar/uvular trill to a uvular fricative, or even a uvular approximant.

There are references to uvular trill pronunciations dating back to as early as 1891 and 1908 (Schiller, 1998), but it was not until 1933 that this pronunciation was allowed by the Siebs dictionary (Russ, 2010: 84). These early references also corroborate the existence of fricative and approximant realisations. In its 1969 edition, this dictionary prescribed an apical trill [r], along with the uvular trill [ʀ] as the "pure" pronunciation for all phonetic contexts (Ulbrich, 1973). Only in coda position in monosyllabic words a vocalised pronunciation of /r/ was admitted, and not as the preferred option. Fewer than 100 years after the Siebs dictionary allowed a uvular trill pronunciation, its use has faded away to a great extent.

According to Ladefoged & Maddieson (1996: 233), uvular approximants are very common in Standard German, especially in medial position, whereas uvular fricatives and uvular trills are more likely to occur word-initially. Similarly, C. Hall ([2]2003: 61) mentions that uvular fricatives are especially common in relaxed, colloquial pronunciation, and in less strongly stressed positions, but notes that "even in the careful pronunciation of trained radio and television announcers it is now the most common pronunciation of /r/". Russ (2010: 60) states that in initial position a trill (either apical or uvular, depending on geographical variation) is to be found, but also points out that in colloquial and informal pronunciation trills are replaced by fricatives or even by approximants. In turn, Kohler ([2]1995: 165) offers some insight into the diatopic variation. According to him, an apical trill can be heard in the domains of Alemannic, and the Austrian-Bavarian area, but also in Schleswig-Holstein. However, he also notes that uvular fricative and approximant pronunciations is the overall dominant pronunciation and is penetrating in the [r]-areas, especially in urban nuclei. He also mentions stylistic variation, as in the case of speakers that would normally produce utterances with [ʁ], for emphatic uses may well pronounce [r] or [ʀ]. In a different work, Kohler (1999) does not even include uvular trills in his description of the German sound inventory for the IPA. In a similar vein, Schiller (1998) claims that nowadays trills, either apical or uvular, are very rare except for the dialects in which have survived, i.e. Bavarian and Northern Saxon. Lastly Schiller & Mooshammer (1995) assert that even in initial position /r/ is hardly ever trilled.

There is also wide consensus that /r/ is vocalised and pronounced as a dark schwa in coda position after a vowel: *Tier* 'animal' [tʰiːɐ] vs *Tiere* 'animals' [tʰiːʁə] (T.A. Hall, 2000: 70). In post-consonantal codas /r/ realisations, there is a strong tendency for devoicing (Hakkarainen, 1995: 88-89), but since such context will not be here investigated no further details are necessary. Once that range of possible realisations and their distribution has been presented, in what follows acoustic and articulatory remarks are provided.

Uvular trill

Ladefoged & Maddieson (1996: 225) describe uvular trills as showing a much higher third resonance than alveolar trills, between 2500 and 3000 Hz in the examples they provide. Lindau (1985) also notes that intervocalic uvular trills tend to be longer, but not in her data.

From an articulatory point of view, there are not many descriptions available in the literature, but Delattre (1971) is very exhaustive in this regard. In his work, it is stated that in uvular trills there are interruptions caused by the contact between the uvula and the back part of the tongue, and that the occurrence of these interruptions ranges from two to six.

Delattre (1971) also mentions that the tongue root moves backwards and upwards, and in so doing gets close to the uvula, which is also moved forward to a position where trilling can occur. Ladefoged & Maddieson (1996: 226-227) note that one might expect the uvula to vibrate faster than the apex, given its smaller mass; however, they claim that the data available to us offer no conclusive evidence. Finally, in Schiller (1998), the uvular trill, the uvular fricative, and the uvular approximant are conceived as different degrees in post-dorsal constriction. He also explains the role of the Bernoulli Effect in the uvular trill, and how the different constriction levels provoke different phonetic results.

Uvular fricative and uvular approximant

Speakers who pronounce /r/ in the uvular region tend to alternate between a fricative [ʁ] or an approximant [ʁ̞]. Their canonical form is voiced; however, due to assimilation processes may become devoiced, even totally, and/or assimilated in place of articulation to a more velar location under the influx of front vowels (Kohler, 1999).

Open-mid central vowel (vocalised /r/)

A detailed phonetic description of [ɐ] is provided in Barry (1995), including a comparison with [ə]. In the author's opinion, auditorily, German [ə] is different from British [ə], being generally more closed in German than in British English. Such perceptions are corroborated by his formant data, in which it becomes patent that German [ə] resembles very closely to [eː] in F1, whilst [ɐ] is considerably more open (his F1 values for [ə], [e] and [ɐ] are 352, 343 and 524). As for duration, according to Barry, the dark schwa is also different to the regular schwa in German, being [ə] just 60.2 ms and 125.5 ms long in pre-tonic and post-tonic position, whilst [ɐ] 71.7 and 162.5 ms long.

2.1.4.3 Summary

Although German has a single rhotic phoneme and Spanish only two, the acoustic description of this section is particularly complex given that the term rhotics masks an amalgam of very different sounds sharing phonemic status. Apart from context-dependent realisations and considerable intraspeaker variation, there is also important diatopic and diaphasic variation in both languages.

Because of the difficulty to define the norm in each community, a comparison between bilinguals and monolinguals is particularly intricate and one must be particularly cautious before concluding that a bilingual speaker departs from the monolingual norm. Such general norm must be understood in a broad enough sense in order to discern between variation that is found even in monolingual speakers and variation caused by the fact of being bilingual.

2.1.5 Concluding remarks on Spanish and German phonetics

Throughout subsections 2.1.1-2.1.4, it has become patent that Spanish and German are very different in the number of their phoneme inventories, as well as in the nature of their phonetic realisations. Whereas Spanish counts with five vowel phonemes that allow great formant dispersion, each vowel phoneme in German occupies a much more reduced space. Consequently, the phonetic realisations of a given Spanish phoneme can fall within the margins for different German phonemes. In sum, L1 Spanish speakers have to learn not only totally new sounds (e.g. /øː/ or /œ/) but also to reorganise their phonological system so that their L1 sounds become different phonemes, e.g. /ɛ/ and /e/.

Stop consonants also present important differences in each language. Both languages present important differences in /b d ɡ/ realisations between absolute initial position and intervocalic position: in German /b d ɡ/ are generally voiceless after a pause but have (passive) voicing when intervocalic, whereas in Spanish they have active voicing in initial position and are obligatorily realised as approximants between vowels. In turn, Spanish /p t k/ are unaspirated voiceless, whereas their German counterparts do have remarkable aspiration [pʰ tʰ kʰ]. Besides, tenseness appears as a secondary feature in both languages.

The repertoire of fricatives also presents important differences. To begin with, Spanish presents more dialectical variation than German, but German has more fricatives than any Spanish variety. Some German sounds are present in the speech of some speakers of Spanish, e.g. [χ] in Peninsular Spanish, [ʃ] & [ʒ] in Argentina, or [ç] in Chile. Conversely, Spanish /θ/ is absent in German.

Additionally, German presents fricatives that differ in being [±voiced] /f/ vs /v/, /ʃ/ vs /ʒ/, and /s/ vs /z/, whereas Spanish has no voiced fricative (except for Argentinean [ʒ] or the relatively infrequent cases in which [j] is a fricative). Finally, even in cases in which the same phoneme is shared between both languages, some differences arise, e.g. Spanish /χ/ is frequently trilled, which has not been observed in German.

Lastly, rhotics also present important differences between both languages. Whereas German has just one phoneme, Spanish has two that only contrast in medial position. Different phonetic realisations are possible in both Spanish and German, but a chief difference can be signalled: whereas in its northern standard variety uvular realisations are the norm for German, in Spanish both trills and taps are produced in the alveolar region.

The phonetic realisations for these four types of sounds, which will be correlated with the ratings obtained for each participant in the global accent task, cover most segments of both languages. Using the data provided in Pérez (2003) for Spanish, it is possible to calculate the frequency of those sound classes in Spanish: 46.23% for vowels, 19.14% for stops, 11.1% for fricatives, and 6.83% for rhotics; i.e. the phonemes here investigated have an accumulated frequency of 83.3%. For the remaining 16.5%, some remarks must be done. The phonemes /t͡ʃ/, /m/, /n/, and /l/ presumably present no acoustic differences between both languages and they account for an additional 15.72% in terms of frequency. It must be noted, though, that /n/ is much more frequently assimilated in Spanish than in German, and /n/ and /l/ can be extrasyllabic in German but not in Spanish. Lastly, /ɲ/ has no acoustic correlate in German, and although both Spanish /j̞/ and German /j/[10] are typically described as voiced palatal approximants, they are by no means alike. Nonetheless, both sounds combined have a frequency of just 0.93% in Spanish. Thus, whatever the total effect of segmental deviations in the perception of global accent is, it is robustly captured in this study.

Similarly, the German sounds here investigated sum up a total frequency of 77.4%, according to Meier's data (1967: 253). Diphthongs and monophthongs were counted together in Pérez (2003), but not in Meier (1967: 253); thus, the values for each language are not entirely comparable, but what is relevant is that most segments of both languages are covered in this research. Interestingly, the frequency of the stops (19.98% in German) and rhotics (7.77%) is very similar in both languages, whereas fricatives are more common in German (16.02%). Vowels in German only account for 33.62% of the total sounds (37.31% including diphthongs); lastly, only 2.05% of the non-investigated sounds correspond to sounds without an equivalent in Spanish, namely, [j], [h], and [ŋ]. The rest of the non-investigated sounds (16.85%) is distributed across [m], [n], and [l], whose only potential difficulties for L1 Spanish speakers

[10] See section 2.1.3 for comments on the symbol discrepancy.

are the tendency to assimilate [l] and [n] with the following sound and the fact that in German they can be extrasyllabic in certain contexts.

Needless to say, not only segments are responsible for foreign accent perception. Firstly, as noted in Ulbrich & Mennen (2016), intonation also plays an important, albeit, according to her, less important than segment production. Furthermore, there are important interactions between intonation and segment production in terms of intensity and duration (Delattre, 1963). Delattre also provides an introductory description of the main differences between Spanish and German regarding intonation, and Lleó & Rakow (2011) specifically for wh-questions.

Secondly, there are different processes that affect both languages at different levels and intensities, namely resyllabification, diphthongisation, and assimilation. A detailed summary of the differences in assimilation between both languages can be found in Lleó (2017).

Lastly, speech rhythm, which is affected by resyllabification (Lleó et al. 2007) must also be considered. Spanish has traditionally been considered as a syllable-timed language (Jun 2005: 432); on the contrary, German is a stress-timed language (Gabriel et al., 2013: 167-179, for a comprehensive review of the differences between these two types of languages). However, as noted in Jun, the distinction between both types of languages is now considered not to be very sharp, and the lack of real isochrony in both types of languages has greatly modified our view of this typological differentiation. In any case, it is clear that both languages are very different in terms of rhythm, whereas the rhythmic/prosodic unit is the foot in German, in Spanish is the syllable (Jun, 2005: 444).

2.2 Bilingual phonetics

The label bilingual covers such an ample gamut of diverse profiles that, from a methodological perspective, becomes too vague and needs to be subdivided into different types of bilingualism: early vs late bilingualism, balanced vs unbalanced bilingualism, etc.

Age of acquisition, amount of input, type of input, L1 & L2 use, language relatedness, language aptitude, and language attitude are often cited as potentially relevant for bilingual acquisition. As will be here reviewed, no author defends that a single factor is responsible for the whole linguistic outcome of a speaker, but rather that all of them are intertwined in ways that are methodologically difficult to control for. Furthermore, the researcher must face the complexity that some factors are naturally confounded.

Depending on which factor is being controlled for, different labels are attached to the term bilingual. For example, if the focus is on age of acquisition, bilinguals can be split up in early and late bilinguals. If, on the contrary, the focus is on the current outcome, i.e. proficiency, it is possible to talk about balanced & unbalanced bilinguals or about active & passive bilinguals. Furthermore, it is also possible to distinguish between bilingualism in a heritage language context (when an individual acquires a language at home which is different than that of the society) and societal bilingualism (in Catalonia, Wales, etc.).

These subdivisions of the term bilingual help us to better deal with bilingualism in linguistic research, but are only more or less arbitrary distinctions, since the reality is far more complex with no clear-cut points between these categories. Is ambilingualism[11] necessary to classify an individual as a balanced bilingual? If not, to what extent can we admit differences in performance in an individual's two languages before beginning talking of an unbalanced bilingual? Is there a certain age after which linguistic performance will irremediably be non-native-like? These and similar questions are methodologically relevant and prove that heterogeneity is undoubtedly one of the main characteristics of bilingualism. Interspeaker variability among bilingual speakers is much greater than among monolinguals simply because more factors need to be considered.

As the title of this dissertation suggests, age of acquisition is undoubtedly regarded as the best predictor for language success. The problem is that age of acquisition *per se* does not tell us anything about why early and late bilinguals show vast performance differences in both global accent ratings and acoustic studies. As will be reviewed, there are three main positions to explain why age of acquisition correlates so closely with linguistic performance:

1) some maturational constraints take place in our brain, after which it is impossible to acquire any language (either L1 or L2) with full mastery. This view is known as the Critical Period Hypothesis and has been redefined several times since Lenneberg's seminal work (1967).
2) age of acquisition confounds with the level of L1 entrenchment in the brain, i.e. the younger bilinguals are at time of L2 acquisition, the less entrenched their L1 is, and thus, their higher success rate. Additionally, being bilingual is intrinsically different to being monolingual because of the interactions between both languages. This theoretical framework is known as the Competing Model (Hernandez, et al. 2005).
3) age of acquisition confounds with other factors such as amount and type of input, motivation and attitude. This view is supported in Flege (1987). According to him, peer-pressure to imitate pronunciation is stronger among children, they monitor their speech to a lesser extent, they are not as attached culturally to their L1, they receive more referential input than adults, and, lastly, their contact with the L2 is very intense because of schooling.

These three views for language acquisition will be reviewed in 2.2.1 referring specifically to bilingual phonetic learnability. In 2.2.2 the focus will rely on language attrition. As will be later exposed in more detail, L2 learnability and language attrition can be regarded as two sides of the same coin. Both

[11] Ambilingualism is the ability to master two languages with virtually equal command in both of them and in all linguistics areas.

phenomena are usually affected by the same factors. Conversely, in 2.2.3 acoustic analyses dealing with specific aspects of bilingual phonetics will be reviewed. Finally, 2.2.4 will aim to bring together all pieces of evidence from 2.2.1, 2.2.2, and 2.2.3.

2.2.1 Bilingual phonetic learnability

The three models for bilingual acquisition sketched in the introduction to 2.2 will be analysed in 2.2.1.1, 2.2.1.2, and 2.2.1.3; lastly, in 2.2.1.4 other factors that probably also affect linguistic acquisition are reviewed, namely aptitude and language relatedness.

2.2.1.1 Maturational constraints

In a seminal work, Lenneberg (1967: 170-182) proposed the existence of a critical period wherein a language can be easily acquired from mere exposition. According to him, if problems arise during this period (e.g. aphasia, deafness etc.), full L1 acquisition is jeopardised. He notes, for instance, that after the ages of 11-14, some aphasic symptoms become irreversible. Interestingly, he also notes that between the ages of 11-14 foreign accents begin to emerge among L2 learners and that learning a second language in the mid-teens and in adulthood is increasingly difficult. However, unlike many authors influenced by his work, he explicitly states two aspects that have been hotly discussed in the literature: a) "most individuals of average intelligence are able to learn a second language" and b) "foreign accents cannot be overcome easily after puberty". In other words, he does not deny the possibility of acquiring a native-like accent and/or fully mastering an L2. What is lost, according to him, is the ability to acquire an L2 from mere exposition. After such critical period, L2 speakers must rely on other learning mechanisms in order to attain a full command of the language.

Later research abandoned Lenneberg's focus on L1 acquisition, and theorised that L2 speakers with full command could not exist, since, given the maturational constraints, acquisition would be impossible or incomplete, regardless of the input received and irrespective of other factors such as practice, motivation, etc. Such maturational constraints have been attributed to cerebral lateralisation or plasticity, among other biological aspects (see Long, 1990, for a review). Soon after the proposal of a critical period, different studies seemingly supported this view showing strong correlations between age and ultimate attainment.

In Asher & García (1969), 30 monolingual speakers of English and 71 Cuban immigrants in the US were recruited. The immigrants had diverse ages of arrival, ranging from 1 to 17 years. Additionally, 19 participants rated the pronunciation of both USA and Cuban born speakers. It was found that no L2 speaker with age of onset older than 6 was identified as a native speaker.

Oyama (1976) offers similar results in her study with 60 immigrants with Italian as L1 and English as L2. Their age of arrival ranged from 6 to 20, and excerpts of the recordings (45 seconds) were presented to two raters. Interestingly, nobody was rated as native speaker after age 12, but substantially before foreign accents began already to appear.

In forthcoming years more studies with large samples also established strong correlations between age of acquisition and ultimate attainment. Flege et al. (1995) carried out a study with data from 240 L1 Italian / L2 English speakers that seemingly supports the Critical Period Hypothesis, although they themselves do not adhere to it. The age of arrival of their participants varies from 2 to 23 and, interestingly, nobody older than 16 at time of arrival performed within the native range in pronunciation. Furthermore, the decrease in native-likeness is very smooth when the arrival took place between the ages 0-8, between the ages 16-22 is slightly more pronounced, but also relatively flat in comparison with the well pronounced change in native-likeness between the ages 8 and 16 (Flege et al., 1995). In even more recent studies, Granena & Long (2013) report to have found evidence for a tiered critical period. In their study of 65 speakers of Chinese who had moved to Spain, age of arrival and pronunciation were very highly correlated, more than any other linguistic aspect. However, Birdsond & Vanhove (2016) interpret the same data in a different way and pose objections based on statistical grounds.

Another study which focuses on different linguistic aspects in L2 acquisition is that of Abrahamsson & Hyltenstam (2009), in which 195 L1 Spanish participants and 20 control speakers (L1 Swedish) took part. Short recordings (20-30 seconds) were presented to a group of raters (10 Swedish monolingual speakers) and the ratings revealed that nobody older than 17 at age of arrival performed within the monolingual range. However, 5 participants whose ages of arrival ranges from 12 to 17 were perceived as native speakers by 9 or even the 10 judges. Some authors would interpret that as counterevidence for the CPH, but Abrahamsson & Hyltenstam do not. These authors sustain that perception criteria do not suffice to declare that somebody performs native-like. In their view, a linguistic scrutiny of the actual performance is essential to validate the ratings of these exceptional speakers. In their linguistic scrutiny on a variety of tasks, they used the lowest native performance as the reference for native-likeness, and native-like command was considered to have been achieved when the participant outperformed the lowest native speaker in all 10 measured aspects. None of the five extraordinary late learners achieved it, and only three early bilinguals (age of arrival ≤ 11) fell within the monolingual norm on all aspects.

Further evidence of possible maturational constraints in linguistic acquisition comes from the study of children with delayed L1 acquisition. The main findings are summarised in Bylung et al. (2012), who review several studies with data from children with prolonged otitis, feral children, and deaf children with delayed exposure to sign language to conclude that delayed exposure to L1 has non-reparable effects. They also defend that the existence of such maturational constraints for the L1 must also apply for the L2.

As seen in the above-mentioned studies, a strong correlation between language attainment and age of acquisition has been established. However, there are important differences among studies. In Asher & García (1969) no speaker with an age of arrival older than 6 was perceived as native, in Oyama (1976) the cutting-point seems to be at age 12, whereas in Flege et al. (1995) and in Abrahamsson & Hyltenstam (2009) at age 16 and 17, respectively.

Attempts to organise such disparity of data have been made in Granena & Long (2013), who propose age 6 as a critical period for phonetic acquisition. After this age, phonetic acquisition would not be impossible, but success rate would be much lower than among very young learners. Likewise, it would decrease gradually until age 12 or soon after it. Thereafter, success rate in the acquisition of a native-like pronunciation would be minimal or zero. Thus, it is not possible to defend the existence of a critical age, *stricto sensu*, after which it is impossible to pronounce like monolinguals, which has been interpreted as counterevidence for the existence of maturational constraints (Bialystok & Hakuta, 1999). On the contrary, other researchers simply do not address this question and implicitly consider the lack of totally abrupt ends after which acquisition is impeded as the result that maturational constraints interact with other factors.

Apart from the fact that these boundaries are too flexible to be compatible with abrupt maturational developments and that they suggest that these gradual maturational changes interact with other factors, several researchers have claimed to have found speakers that invalidate the existence of maturational constraints. Such claims usually echo Long’s (1990) famous claim theorising that one single post-puberty speaker ranging among monolingual norm would be enough to refuse the CPH.

Ioup et al. (1994) provided one of the most cited examples of successful L2 learners in acquiring a native accent. In their study, the Arabic of two speakers, Julie and Laura, was tested. Whereas Julie was married to a local English teacher and had lived for 26 years in Egypt at the time of the study, Laura, who holds a PhD in Arabic linguistics and is a teacher of classical Arabic, had lived in Egypt for 10 years. They were tested in several linguistic aspects, including pronunciation. A panel of 13 teachers of Arabic listened to their recordings along with those of three native speakers and two more L2 speakers with a noticeable accent; 8/13 of the judges in the panel thought them to be native after listening to their recordings. Unfortunately, no indication is given about the length of the recording. Remarkable as it may be, it is still very far from the L1 norm, since all L1 speakers of Arabic were consistently marked as native speakers by the totality of the panel.

Another exceptional learner is described in Molnár (2010). In her study, one participant (a linguist) fell within native norm in pronunciation. One methodological flaw is that only 4 raters participated in the study, but what invalidates this learner as counterevidence for the CPH is the fact that the age of acquisition of this speaker is 11.

Muñoz & Singleton (2007) also claimed to have found participants with a native-like accent in their L2. In their study 2 participants with virtually no use of L1 performed within the monolingual norm. Again, there are founded reasons for scepticism, not only because just 4 native speakers composed the jury, but particularly because the extracts presented to the jury were only 8 - 11 syllables long. Such a short recording raises the question of whether the researchers are proving the existence of individuals able to acquire a native-like pronunciation or the existence of individuals able to mimic native speakers for some seconds.

Nikolov (2000) also found evidence contesting the validity of the CPH. In her study with 33 participants who had started their learning at age 15 or later, three late learners were perceived as native speakers (two of them by almost all raters). Two participants accomplished that in Hungarian and one in English. The recordings were 35 seconds long approximately, and this time the number of raters guarantees statistical reliability (57 L1 Hungarian and 34 L1 English raters). The findings of these two speakers were not replicated using longer excerpts or linguistic tests.

Another study worth mentioning is that of Moyer (1999), in which 24 American teachers of German at university level participated. Four native raters used a scale from 1 - 6 for their ratings; 1 equalled to definitely native and 6 to definitely non-native. The means are 2.63 and 4.98 for the groups of monolinguals late learners, respectively, and their ranges are 2.13-2.88 and 4.25 - 5.75. It must be noted that one outlier was excluded for these calculations. Interestingly, this speaker, who was not exposed to German before the age of 22, fell within monolingual norm (mean rating of 2.13). It particularly interesting that this speaker explicitly professed a desire to sound native in German and was fascinated for German culture.

Hopp & Schmid (2013) report 11 late learners who were perceived as native speakers in a rating task by a very large sample of raters. The recordings were 10-20 seconds long, and the most important predictor for native-like accent in their study was the fact of having a native-speaker partner.

Further evidence threatening the validity of the CPH comes from a series of studies carried out by Bongaerts et al. (1995, 1997, and 2000). In their first study, ten Dutch late-learners of English were recruited and recordings ranging from 10 - 16 seconds were presented to a panel of native speakers. All the L2 speakers worked as English teachers, most of them at university level. Surprisingly, five of them not only fell within monolingual norm, but even outperformed the monolinguals in the study. Native speakers received a mean rating of 3.94 (5 was the maximal score and 4 signalled a “slight foreign accent”). The authors provide an explanation for their anomalous finding, namely that the monolingual speakers had hints of regional accent, whereas the university teachers spoke standard British English.

With all likelihood this affected the panel’s judgments and in 1997 the authors decided to replicate their previous study, this time with 11 Dutch speakers (9 of whom had also participated in the first study) and 10 native English speakers without traces of regional accent. Their recordings of six read-aloud sentences were evaluated by 13 native raters and this time the means are substantially different to those of the previous study. Mean rating for the natives was 4.84, whilst 4.61 for the L2 speakers. Five speakers, again, fell within the monolingual norm.

Lastly, Bongaerts et al. 2000 carried out another study with 10 monolinguals and 30 advanced learners of Dutch older than 12 at age of arrival and with different L1s. The accent of these participants was evaluated by 21 Dutch raters, who gave ratings ranging from 1 to 5. The mean score for the control group was 4.73, and the range oscillated between 4.58 and 4.91. On the contrary, the L2 speakers mean was 3.5, ranging from 1.70 to 4.59. Only 2 out of 30 late learners of Dutch achieved a score higher than 4.5, that is within their lower native range. Interestingly their L1s were English and German and both were married to Dutch women, lectured languages at Dutch universities, and had a strong interest in pronunciation. Likewise, the best non-natives were mostly speakers of related languages, German and English.

As can be seen, speakers who allegedly perform native-like in terms of pronunciation are, at the very best, the exception rather than the norm although many of those studies screened out highly proficient speakers during the recruitment process. Nonetheless, according to Long (1990), such scarce counterevidence would be enough to reject the strongest version of the CPH, i.e. that no acquisition is possible to be complete after a certain age.

On the contrary, the lightest version of the CPH can still be reconciled with those exceptional learners. In this version, maturational constraints do operate in language acquisition, but instead of a critical period, a sensitive one would take place. The rationale behind this light version of the CPH is that the correlation between age and L2 attainment is robust and only a bunch of speakers have been claimed to pronounce native-like after decades of exhaustive search and, therefore, maturational constraints cannot be denied, although it would be still possible to overcome such constraints developing alternative learning strategies.

However, it is far from clear that those allegedly exceptional learners exist. Abrahamsson & Hyltenstam (2009) proposed that further steps should be taken before claiming that maturational constraints operate no role in L2 learning. As reviewed before, they signal the need of linguistic scrutinies for those exceptional learners beyond global accent ratings.

In a similar vein, simple measures like presenting longer excerpts to the raters should be adopted before concluding that an L2 learner has attained native-like pronunciation. It seems reasonable to use at first extracts just 15-30 seconds long, since natives all over the world have proved to be extremely skilled at sorting out L1 and L2 speakers in extremely short periods of time (Flege, 1984 and all above-cited works). Interestingly, even participants with no knowledge of the tested language can discriminate between natives and non-natives with almost the same degree of accuracy (Major, 2007). However, the fact that many monolingual native speakers have also been perceived as non-native speakers clearly goes against the validity of this procedure as the single testing instrument. Besides, the use of 15-30 second excerpts only proves that an exceptional learner can deceive a jury of native speakers for such amount of time. If we would not accept a half-page piece of writing with no grammar mistake produced by an L2 speaker as evidence of native command in writing/grammar, there is no reason to accept extremely short recordings as a proof of having acquired native-like pronunciation.

My proposal is, therefore, that short extracts continue to be used, but, in the extremely rare cases in which seemingly exceptional learners are found, further measures should be taken. Firstly, longer extracts should be presented to the same or new raters. If we posit that there is no maturational constraint whatsoever, then it follows that an L2 speaker should be able to speak native-like for much longer than a minute. Secondly, a linguistic scrutiny in form of acoustic analyses for pronunciation is necessary, as noted in Abrahamsson & Hyltenstam (2009).

Apart from these additional measures, it is also possible to minimise the possibility of detecting false positives by using many raters, which ensures greater reliability. Secondly, it is also important to allow non-binary judgements. Although native-likeness is a binary phenomenon (Abrahamsson & Hyltenstam, 2009), non-binary judgements allow us to detect minor differences in short recordings; if bilinguals are consistently rated as ‘probably native’ whilst monolinguals are consistently rated as ‘in all certainty native’, it becomes evident that there is something detectable in their pronunciation.

Apart from the, in my view, unsuccessful attempts to prove the existence of individuals challenging the maturational constraints proposed in the CPH, there have been different approaches to reject the validity of this hypothesis based on methodological objections and reminding that correlation does not mean causation (Bialystok & Hakuta, 1999). One of their most pertinent criticism is that, in their view, research has shown no abrupt discontinuity in ultimate attainment (Bialystok & Hakuta, 1999), which according to them is the minimal essential evidence to verify the CPH. These authors supported their argument with self-report data from the US-census. On the contrary, authors like Granena & Long (2013) and De Keyser (2000) defend the existence of such abrupt changes in ultimate attainment. For pronunciation, a discontinuity after the age of 6 has been signalled (Asher & García, 1969; Long, 1990), and a second one after age 12 (Long, 1990; Oyama, 1976), but also discarded in Bialystok & Hakuta (1999). As mentioned before, it is far from clear what exactly changes in the brain and is supposedly responsible for our loss of the ability to acquire both L1s and L2s native-like in adulthood, but the evidence is only compatible with maturational changes that take place over several years, irrespective of the fact that there might be some abrupt changes.

A further aspect that would help to explain the lack of a well-defined critical moment is the interplay with other factors (amount of input, motivation, etc.). This view has already been defended by Hyltenstam & Abrahamsson (2003), who defend that it would be too simplistic to defend that age of acquisition is exclusively responsible for ultimate attainment. To begin with, because speakers not all bilinguals who start acquiring a language at a very young age are able to acquire a native-like accent, but also because of the very different outcomes in pronunciation for those who being the acquisition of their L2 between the ages of 6-12.

Abrahamsson & Hyltenstam (2009) state that L2 proficiency in individuals with low starting ages is considerably less common than previously assumed. In their study, 195 bilinguals (Spanish & Swedish) took part, all of whom identified themselves as potentially native-like in Swedish. 107 began learning Swedish before age 12, and 88 at that age or later. Short recordings were presented to 10 native speakers of Swedish and the authors found that only 62% of the early bilinguals (i.e. $\leq$ 11) were perceived as native speakers by 9 o 10 judges. They also present the data split up into two groups Early childhood <1-5 & Late Childhood 6 -11. The former is slightly closer to the control group, but the differences between this group and the latter are small and not statistically significant.

Those results are not new, since in the pioneering study of Asher & García (1969) previously mentioned there was already a 32% of speakers younger than 6 at arrival who had a slight foreign accent. Likewise, Flege et al. (1997) detected a mild foreign accent among early bilinguals (L1 Italian – L2 English).

In sum, defendants of the CPH have succeeded in showing very robust correlations between age of acquisition and linguistic performance and count with solid evidence from delayed L1 acquisition but have failed to identify the exact maturational changes responsible for these differences. Furthermore, the that fact individuals whose linguistic exposure began at a very early age and did not perform monolingual-like, whereas others who started their L2 acquisition relatively late (around 10) were completely successful, is not compatible with a critical period *stricto sensu*. Consequently, whatever the importance of maturational constraints might be, the interaction between them and other variables must be considered in order to fully understand how bilingual acquisition takes place.

2.2.1.2 The Competing Model

It has been proposed that there is no need to invoke a critical period, as being bilingual is different in nature to being monolingual. The two languages are not stored in two separate brains and, thus, an "competition" is expected among them. Furthermore, the level of L1 entrenchment also confounds with age of acquisition.

Hernandez, et al. (2005) note that their "emergentist account provides a very different explanation for age-of-acquisition effects" and note that years of L1 consolidation and entrenchment lead to more automatic L1 control and to "increasingly more committed neural substrates".

If we posit that L1 entrenchment hinders L2 acquisition, then it follows that those linguistic aspects that have become more automatic should be more entrenched and thus more difficult to acquire in the L2. Indeed, the existing evidence supports this claim; as reviewed in Granena & Long (2013), native-like pronunciation is much more difficult to achieve than native-like morphology, syntax, and lexicon after the age of 6.

In their view, automatic processes provoke neuronal changes in the brain; however, they implicitly accept that some maturational constraints do operate in linguistic acquisition, as they seemingly make theirs the position defended in Bates (1999), who highlights the importance of the higher brain "plasticity" among early bilinguals. This leads to a lighter version of the competing model, wherein L1 experience leads to a progressive level of linguistic entrenchment which triggers neuronal changes in the brain, but also affected by maturational changes that are independent of linguistic exposure, namely brain plasticity.

This lighter version is compatible with the evidence from the study of L1 delayed acquisition (whereas denying maturational constraints is irreconcilable with it) and with the seemingly gradual changes in linguistic learnability. Furthermore, it would also explain the differences in simultaneous bilinguals, whose age of acquisition in their two languages should lead to native-like performance in their two languages given that no maturational constraints operate on them. However, they are typically unbalanced and perform better in their societal language than in their heritage language, which is compatible with a higher level of linguistic entrenchment in the language in which most interactions take place. In addition, as will be reviewed in 2.2.2, languages can be totally forgotten before puberty, whereas not thereafter. Schmid (2010) specifically mentions linguistic entrenchment as a plausible reason whereby linguistic knowledge is little affected even after decades of non-use or exposure.

Lastly, it is worth nothing that even the lighter version of the Competing Model must be extended to include not only the above-mentioned changes in brain plasticity, but also individual aspects in order to be compatible with the differences in linguistic acquisition reported in the literature. If linguistic entrenchment were the sole variable affecting linguistic outcome, then those early bilinguals with little use of their L1 should attain higher levels of L2 competence than those who use both languages regularly. However, there is contradictory evidence in this regard.

Flege et al. (1997) found that their early bilingual participants with low use of L1 were closer to native norms. Similarly, Yeni-Komshian et al. (2000) found in a global pronunciation task that language use affected both the L1 and the L2 of those who started the acquisition of the L2 before 12, but not after that age. On the contrary, L1 use cannot explain Hyltenstam et al. (2009)'s results, since their four participants are Latin American adoptees in Sweden who ceased to use Spanish completely. Their ages of arrival were 1, 2, 4, and 9, i.e. all of them can be labelled as early bilinguals, especially those whose age of arrival was 1, 2, and 4. However, in terms of pronunciation, only the participant who was adopted at the age of 1 was the only one to be consistently perceived as native speaker. Lastly, Bylund et al. (2012) found that L1 maintenance does not hamper L2 acquisition; indeed, in their study both were positively correlated. Likewise, the only speaker out of five who achieved a native-like Greek intonation in Mennen (2004) was the same that had kept intact their L1 Dutch intonation. In sum, the evidence in this regard reinforces the idea that other variables should be incorporated to the Competing Model.

2.2.1.3 Confounding factors with age of acquisition: L1 use & L2 amount and type of input

Both the Critical Period Hypothesis and the Competing Model have in common that they depart from an irrefutable evidence: age of acquisition correlates very closely with linguistic outcome. They differ, however, on the origin for this correlation; whereas the former emphasises the maturational changes, the second focus on the levels of L1 entrenchment; in turn, other authors have put the focus on some factors that easily confound with age of acquisition, for which it has been argued that, from a strict methodological point of view, it is impossible to reject the CPH (Flege, 1987). This author notes that it would be completely impossible to select a pool of children and adults controlling for all factors. Such factors are peer-pressure to imitate pronunciation (stronger in children), a lesser degree of speech-monitoring, quantity of input (children allegedly receive a more intense contact with the L2 due to schooling), type of input (children are usually addressed to with more referential language, whereas adults with a more abstract one), and covert prestige (an adult is expected to have a stronger desire to keep its culture and accent as marks of cultural affiliation). Flege[12] even states the following in his personal website:

> [...] nearly all adults lack one or both of the two ingredients that are essential for successful language learning at any age. Every child who learns an L1, but very few learners of an L2 have these to magic ingredients: the **availability** of large amounts of authentic input from native speakers and a compelling **need** to use that language for everyday communication.

In my view, the problem with such objections is that, given the inexistence of post-puberty native-like L2 speakers, we should consequently assume that no adult has ever had such optimal conditions, which is simply not plausible. Millions of people are married to native speakers of their L2, work every day using their L2 for extended periods of time, and yet have a recognizable foreign accent. It is simply not plausible that among millions of adults migrating to other countries no one has ever been in the optimal conditions to fully acquire a language native-like.

Furthermore, it must be noted that late bilinguals that have lived for decades in a country do not outperform early bilinguals that have lived in a country for 8 or 10 years. Additionally, if amount of input were the most important factor in bilingual development, differences in pronunciation would be expected to be minimal in comparison with other linguistic aspects, since the amount of input required to have enough examples of the intonation patterns and phonetic aspects of a language is much more modest than that required to encounter all grammar structures and lexical elements and, yet, native-like

[12] http://www.jimflege.com/about_me.html

performance in pronunciation is more difficult to acquire than grammar or lexicon. Lastly, Flege's (1987) proposal cannot account for the fact that that pronunciation, whose input is much more numerous than that of any other linguistic aspects, is precisely the most difficult linguistic aspect to acquire at native level.

Despite these considerations, it would be erroneous to think that amount and type of input and motivation to sound-native like have no influence whatsoever on the phonetic outcome. As reviewed in 2.2.1.2, several studies did find an effect of L1 use on L2 performance.

Likewise, even admitting that Flege is undoubtedly right in claiming that early bilinguals have more powerful reasons and a stronger desire to adapt to the community norm (social prestige) than to keep an accented L2 as a sign of group membership of the L1 community (covert prestige), it would be expected that among millions of late bilinguals many of them felt such a strong desire to sound native-like. Having an L2 accent may not only severely reduce somebody's employability, but also converts the speaker into a potential target for racist attacks and/or stigmatisation[13]. Despite these good reasons to get rid of their L2 accents, late bilinguals consistently retain their foreign accents, as reviewed in 2.2.1.1.

Nonetheless, it should not be concluded that motivation to sound native-like has no influence whatsoever. Moyer (2014) emphasises vigorously its importance and offers of a review of allegedly exceptional learners and notes that extroversion and lack of risk aversion is also a recurrent commonality among participants across different studies. Acquiring a native accent involves not only the discrimination of foreign sounds, but also its production, for which many attempts are necessary. Additionally, some phonetic features are impossible to be acquired if the speaker constantly pursues to avoid grammar mistakes; this can be better illustrated with an example. If a learner of Spanish is constantly paying attention to the correct gender or the correct grammatical ending, its speech rate will inevitably be reduced and, consequently, most synaloephas, resyllabifications, assimilations, and elisions will not be produced.

Furthermore, after my own review of allegedly exceptional learners (2.2.1.1), it can also be concluded that a proactive approach is essential. All participants in the review had an expressed desire to sound native-like as well as a desire of belonging to the L2 community and made serious and constants efforts to achieve an L2 command comparable to that of natives (Bongaerts et al., 2000; Nikolov, 200; Moyer, 1999 & Ioup et al., 1994).

Flege also notes that children monitor their speech to a lesser extent. Interestingly, Guiora et al. (1972) found that adults can pronounce better after a moderate consumption of alcohol or placebo. In a similar

[13] Different investigations on the effect of both regional and non-native accents are listed in: https://accentism.org/research/

vein, deeply hypnotised subjects pronounced Thai words better than less well hypnotised (Schumann et al. 1978).

In sum, all the aspects mentioned in Flege (1987), i.e. amount and type of input, motivation to sound native-like, and the way adults monitor their speech, undoubtedly form part of the complex group or variables that affect linguistic outcome. However, these variables are not compatible with the strong correlations found between age of acquisition and linguistic proficiency. Either because of linguistic entrenchment in the brain or because of maturational changes (or because of a combination of both) what is clear is that something impedes adult learners to sound native-like. Whatever it is, however, it is also clear that interacts with the aspects proposed in Flege (1987) and with those in 2.2.1.4

2.2.1.4 Other variables: the role of aptitude and language relatedness

Apart from the maturational constraints (2.2.1.1), the level of linguistic entrenchment (2.2.1.2), and the variables signalled by Flege (1987) such as type and amount of input and motivation (2.2.1.3), there are, at least, two more that deserve attention: linguistic aptitude and language relatedness.

It is common knowledge that some learners need fewer explanations to acquire certain grammar patterns and that some are better than others at mimicking accents and perceiving sounds absent in their L1. In other words, some speakers show better language aptitude than others. This factor may have a much higher impact than previously assumed. Unfortunately, it has received little attention so far; probably because of the methodological difficulties that it poses. Whereas length of residence can be easily calculated, or amount of input and use can be inferred from self-reports (albeit perhaps with little accuracy), measuring language aptitude is complex. Some tests have been developed, e.g. the Swansea Language Aptitude Test (Meara et al. 2003), but its use irremediably implies longer testing sessions.

In Bylund et al. (2012) aptitude was found to correlate very significantly with proficiency in both L1 and L2 and, indeed, was a better predictor than length of residence. In a similar vein, De Keyser (2000) found out that aptitude did not predict successfully L2 acquisition during childhood but was a powerful factor to account for his late bilinguals' near-native proficiency. It is also worth highlighting that many of the subjects that have been claimed to sound native-like are linguists or university language teachers (Bongaerts et al., 2000; Moyer, 1999 & Ioup et al., 1994). Of course, being a linguist or a language teacher does not necessarily imply that your language aptitude is over the average in the normal population, but, as a group, linguists are undoubtedly more likely to have a higher language aptitude than, say, pharmacists or tax consultants.

Apart from the problem of reliably measuring language aptitude (and, if possible, in non-excessively time-consuming tasks), it is to be noted that, anew, factors are easily confounded. People rarely feel strongly motivated for something they are awful at. Thus, aptitude and attitude irremediably interact with each other to some extent. A linguist or a language teacher is expected to have a special touch for languages, but also a strong desire to sound native-like or to reach high levels of proficiency.

Further objections to the role of language aptitude appear in Long (1990). According to this author, if cognitive development were heavily implicated in language development, IQ differences should have much more influence on rate and achievement in L1 acquisition than they have. However, it is plausible to think that this variable affects individuals with different intensities over time. If early linguistic acquisition is easier because some maturational changes have not taken placer and/or because of a smaller degree of L1 entrenchment, it is reasonable to think that language aptitude will play a more important role the later the acquisition process begins (and the more complex a given linguistic aspect is). This goes in line with De Keyser's study (2000), in which aptitude was not important during childhood, but very relevant in adulthood. Thus, language aptitude is more relevant after puberty, when the conditions for language learning are not optimal.

Finally, it is also common knowledge that speakers find some languages easier to learn than others. For instance, all other factors being equal, a speaker of Spanish will progress more when learning Portuguese than ǂhõã (a Khoisan language spoken in Botswana). Bialystok (1999) offers data on self-reported English proficiency of thousands of immigrants in the US and signals that the Hispanic community reported higher values than the Chinese one. It is possible, of course, that cultural factors are also responsible for differences in self-assessment.

In a similar vein, the best L2 speakers of Dutch in Bongaerts (2000) were mostly natives in German and English. Likewise, in Hopp & Schmid (2013), Dutch speakers were generally perceived as native-like in German more often than English speakers. One could argue that similarities in the phonetic and intonational repertories are perhaps more important than affiliation to the same linguistic branch or family. However, it is also plausible to assume that if grammar structures and lexicon resemble in both languages, speakers are partially freed to concentrate in those aspects and can pay more attention to pronunciation.

2.2.2 Language attrition

Language attrition, as defined by Schmid & Dusseldorp (2010), refers to:

> [...] a change in the native language of the bilingual who is acquiring and using an L2. This change may lead to a variety of phenomena in L1, such as interferences from the L2 on all linguistic levels [phonetic, lexicon, morphosyntax, pragmatics], a simplification or impoverishment of the L1, or insecurity on the part of the speaker manifested by frequent hesitations, self-repair or hedging strategies.

It has also been defined as any change in production that does not characterise typical speakers of the same language and dialect and which may vary from slight modifications to complete loss (Major, 2010).

Both definitions are broad enough to encompass two phenomena that are different in nature. Whereas, lexical or grammatical attrition is generally understood as a loss or an impoverishment in either linguistic competence or performance, what happens with pronunciation is perhaps best described in terms of phonetic convergence or phonetic merge (see Hopp & Schmid 2013 for a discussion on the topic). Incorporating L2 phonetic patterns into the L1 is different in nature to a momentary or permanent lack of retrieval of lexical elements. Speakers can hesitate whether a construction is valid or not, pause trying to find the right word, but are never reported to babble trying to produce a sound of their L1; they simply adopt traces of the phonetic and/or intonational patterns of the L2. For instance, some of De Leeuw et al.'s (2017) participants alternate realisations of /l/ that were judged to be native-like with foreign pronunciations, and in Flege (1987) and Major (1992) both the properties of some segments in both the L1 and L2 are modified in the bilinguals' speech undergoing partial convergence.

It is worth noting that language attrition and L2 ultimate attainment can be viewed as two sides of the same coin. The relevance of the study of language attrition for our understanding of bilingualism has been already defended in Schmid (2010), but L2 learnability and language attrition are still seldom investigated jointly, neither findings from one field are usually related to those from the other. In this section, the findings from the field of language attrition will be compared with those of L2 learnability. The relation between the findings in both fields of research is so striking that this can hardly be attributed to chance.

As noted in 2.2.1, Granena & Long (2013) defend that most speakers attain a native-like pronunciation when the acquisition takes place between the ages of 1-6, whereas much fewer speakers have a native command of pronunciation when the age of acquisition ranges from 6-12. Interestingly, the literature on language attrition has also signalled puberty as the crucial point at which an L1 can be forgotten or not (see Köpke 2004a for an extensive review). The most extreme version of language attrition, i.e. L1 loss, has only been documented in speakers who ceased to use completely their L1 before puberty (Schmid et al., 2012, and Schmid & Dusseldorp, 2010). Conversely, speakers who moved to a country with a different language after puberty have systematically retained their L1 astonishingly well in spite of virtually no use of the language. Furthermore, whether an L1 can be *completely* lost is still a matter of discussion. In Fromm (1970), a speaker who assured to speak no Japanese at all was hypnotically age-regressed with some unexpected linguistic success. However, the study is unfortunately little reliable owing to several methodological flaws. A similar case was published by Ås (1962), with very modest, and yet interesting, linguistic recovery. On the contrary, the L1 Korean adoptees in France tested in Ventureyra et al. (2004) were unable to discriminate Korean phonemes better than French monolinguals.

These relationship between language attrition and age seems to be particularly compatible with the Competing Model. Grammatical knowledge, syntax, and pronunciation are much more resistant (Hopp & Schmid, 2013) even after decades of scarce or even virtually no use of L1 (Schmid, 2010):

> [...] large areas of this knowledge appear to be so entrenched that they are affected to a surprisingly small degree by non-use and non-exposure, even if the speaker has lived in a migrant setting for several decades.

Similarly, Schmid (2007) has observed that lexicon is typically attrited to a greater or lesser extent and, as exemplified in Stolberg & Münch (2010), (partial) recovery can take place quite rapidly. In sum, it seems that those linguistic aspects that are less automatic, such as lexicon, are more prone to linguistic attrition than those that are first acquired and heavily entrenched in the brain, such as pronunciation.

It is also worth discussion the relation between language attrition and language aptitude, but unfortunately few data are available. According to Bylund et al. (2009), it interacts with language use. If language aptitude is low, a low amount of L1 use favours language attrition; on the contrary, if language aptde is high, L1 use does not influence the degree of attrition. No other factor under investigation in this study was found to show correlations with attrition. Lastly, both the data in Bylund et al. (2012) and Hopp & Schmid (2013) also seem to support the importance of language aptitude.

In turn, language use has been more widely studied as a possible source for language attrition, but the evidence available is contradictory. Schmid (2007), in a study measuring lexical diversity and fluency, found “little or no correlation” between the participants’ results and their self-reported language use. Along the same line, De Bot & Clyne (1994) found no correlation between attrition and language use (and virtually no sign of attrition in their speakers) after measuring different lexical and syntactic aspects. Perhaps the most relevant aspect of their study is that they suggest that attrition is not linear. Once a certain level of attrition is reached (or after a given period in the new setting), a considerable increase in the length of residence will follow to none or minor increases in the level of attrition. In a similar vein, Schmid & Keijzer (2009), express that:

> With increasing proficiency and fluency in the L2 and increasing practice in inhibiting one language system when switching between the two, both the 'learning' and the 'forgetting' curves may eventually stabilise: as ultimate attainment (or fossilisation) in the L2 is reached, attrition effects in the L1 will also slow down.

In De Leeuw et al. (2010), it is suggested that language use is only relevant if interactions are carried out with no code-switching. On the contrary, in De Leeuw et al. (2007), L1 use was found to be a better predictor than age of arrival for their L1 German bilinguals living in The Netherlands and Canada. It must be noted, however, that the minimum age of arrival was 14 (mean age of arrival in Canada was 25 and 30 in The Netherlands) and the length of residence was generally very high (a minimum of 9 years, but the means for those settled in Canada was 38 and 34 for those residing in The Netherlands). The fact that all speakers are post-puberty learners probably accounts for the lack of correspondence with age of arrival; similarly, if De Bot & Clyne (1994) are certain and attrition is not linear, the long residence periods of most participants in De Leeuw et al. (2007) may have obscured the relation between attrition and length of residence.

Unfortunately, the relation between language attitude and attrition is mostly under-investigated in comparison to the above-mentioned factors. The review in Schmid & Dusseldorp (2010) suggests that both positive and negative attitudes towards the L1 have beneficial and harmful effects on L1 maintenance. It must be noted, however, that investigating linguistic attitude is also methodologically problematic, since both negative L1 attitudes and positive L2 attitudes result in more interactions in the L2. Thus, this variable becomes confounded with amount of input.

Finally, to my knowledge, only two studies have (indirectly) addressed the role of language-relatedness in attrition. In Hopp & Schmid (2013), the proximity between Dutch and German in comparison to English and German seemed to slightly favour L1 maintenance for speakers in The Netherlands over those in Canada. On the contrary, in Schoenmakers-Klein Gunnewiek (1998), as cited in Köpke (2004b), Portuguese speakers underwent more severe language attrition in France than in The Netherlands, perhaps as a result of the greater size of the Portuguese-speaking community in France.

2.2.3 Acoustic analyses on bilingual phonetics

Most of the evidence reported in 2.2.1 and 2.2.2 came from global accent ratings; on the contrary, the evidence here reported focus on specific aspects of bilingual phonetics. In so doing, a better understanding of how the two languages interact will be provided.

To my knowledge, the combination Spanish-German bilingualism has only been studied in children. Kehoe et al. (2004), Lleó & Vogel (2004), or Lleó et al. (2004), among other works, have carried out very valuable research for this language combination, but, since a comparison between individuals with developing and developed phonological systems would be inappropriate, it has been decided to review other studies involving adult speakers of either German and Spanish plus other language. It has also been attempted that the other language largely patterns Spanish or German in the phonetic aspects investigated.

Whereas there is no study involving Spanish or German in the bilingual production of fricatives, vowels are among the segments that have received considerable attention. For instance, in Amengual & Chamorro (2015), the perception and production of Galician vowels were investigated across a sample of 54 early and highly proficient Spanish-Galician bilinguals. Unlike Spanish, Galician patterns with German in having both front and back close-mid and open-mid vowels, i.e. /e/ vs /ɛ/ and /o/ vs /ɔ/. Interestingly, despite their high proficiency and early exposure to Galician, Spanish dominant bilinguals merged /e/ and /ɛ/ in a single category, whereas the contrast for the back vowels was maintained in both groups.

In contrast, Spanish-Catalan early bilinguals in Bosch & Ramon-Casas (2011) did keep the /e/ vs /ɛ/ contrast in Catalan irrespective of the language(s) spoken at home during childhood, but those who solely spoke Catalan presented more robust contrasts.

Also dealing with early bilinguals, Ronquest (2013) presents evidence from Spanish-English bilinguals which is not fully conclusive, since it is unclear whether her bilinguals showed more vowel reduction in their heritage language due to their interaction with the societal language or as a result of the variety spoken by their Mexican parents.

Konopka & Pierrehumbert (2008) also dealt with Spanish-English early bilinguals but focused on their L2 (English) and measured duration and vowel formants among early and late Spanish-English bilingual speakers in Chicago. As expected, late bilinguals differed enormously from monolinguals, whereas early bilinguals established distinct categories from each phoneme; however, they differed from monolinguals in not fully participating in the regional vowel changes taking place in the area.

Lastly, Bergmann et al. (2016) carried out the only acoustic analysis on language attrition involving vowels to my knowledge. In their work, formants for three German vowels and for /l/ were measured for a pool of 33 late bilinguals residing in the US or Canada (L1 German). Whereas 40% of the speakers showed attrition in a global accent task, their ratings "weakly associated" with formants data. Thus, the authors conclude that the main source for the attrition cannot be the investigated sounds: /aː/, /ɛ/, /ɔ/, and /l/.

Regarding stops, there is also relatively extensive evidence between a bilingual's two languages interaction. Lein et al. (2016) provide a thorough summary for VOT in early bilinguals (French & English) in Canada. Although the situation in which they acquired their languages is different to that of the participants of this study (in Canada it is possible to have regular and extensive access to both languages outside family context), the findings from those studies are suitable for comparison owing to the fact that French and English VOT largely patterns with those of Spanish and German, respectively. According to Lein et al. (2016), generally, VOT values are identical to those of monolinguals in both languages across those studies. In their own study, comparing VOT in German-French bilinguals grown up in France and Germany, they found that both groups maintained different VOT for each language. There were, however, group differences between residents in Germany and France. Furthermore, no correlation could be established between foreign accent ratings and VOT values.

Fowler et al. (2008) also investigated early French & English bilingualism in Canada and found that their bilinguals produced shorter and longer VOT values than English and French monolinguals, and, yet, kept distinct VOT values for each of their languages. Interestingly, their language dominance was also reflected in their VOT values.

In like manner, Gabriel et al. (2018) also found evidence of convergence in their early bilinguals with either Russian or Turkish as their heritage language and German as their societal one. Their German /p t k/ tokens are slightly less aspirated than those of their monolingual peers, whereas their Turkish/Russian ones are considerably more aspirated than the respective monolingual norm.

Furthermore, their /b d g/ tokens in Russian and Turkish also exhibit influence from their societal language, i.e. German.

In Kupisch et al. (2014), among other linguistic parameters, VOT and global accent were investigated in two groups of early French-German bilinguals; one of them had been raised in Germany, whereas the other one in France. Bilingual speakers of French grown up in Germany were considered to be native in French significantly less often than those grown up in France. Additionally, French-born bilinguals did not differ in VOT from French monolinguals, but Germany-born bilinguals did differ from French monolinguals significantly.

Similarly, Kupisch & Lleó (2017) investigated early bilingual speakers of Italian and German residing in both Italy and Germany. Their work also shows merging in the group means, and the powerful influence of societal language over family language also becomes patent, since those bilingual speakers residing in Germany deviated lees from German monolingual norm. Besides, individual variation was very ample.

In Stoehr et al. (2017), late bilinguals with L1 German living in The Netherlands produced different VOT values for each language (Dutch behaves like Spanish in terms of VOT; Gussenhoven, 1992), but whereas the differences between their German VOT and that of monolinguals are small (i.e. small attrition), their VOT differs greatly from that of Dutch monolinguals.

In turn, investigations involving rhotics are much scarcer. Thy only study in this direction known to me is Henriksen (2015), who investigated rhotic production in a bilingual community (Spanish and English) in Chicagoland among early and late bilinguals. Both groups presented great variability in the production of both the phonemic tap and trill, which patterns with the findings from the literature for Mexican and non-Mexican Spanish dialects. The individual analysis also reveals that some speakers clearly favour one realisation over the others, whilst in others no tendency can be identified. Differences between groups were small and not significant, although they go in the expected direction: first generation speakers tend to produce more articulatory complex trills, i.e. they produced trills with more contacts (1.20) than second generation speakers (1.10). What becomes patent amidst the great phonetic variability of these G1 and G2 speakers is that, irrespective of the phonetic form chosen, the phonemic contrast was maintained at least by means of duration, which was significantly different in both groups except for one G2 participant. This is in full accordance with monolingual production; see 2.1.4.1.

Lastly, although neither intonation nor speech rhythm are part of this investigation, it is also worth dedicating some lines to these aspects, since segmental phonetics are not expected to be exclusively responsible for global accent.

Coetzee et al. (2015) investigated mutual influence in speech rhythm between L1-Afrikaans (also the dominant language until their early adulthood) and L2-Spanish (dominant language for the past three or four decades) speakers in Patagonia (Argentina), and concluded that these speakers "generally patterned with Spanish monolingual speakers and showed little influence from [...] Afrikaans". Similarly, for consonant metrics, they also patterned with Afrikaans monolinguals, but, on the contrary, some influence from Spanish was visible in their vowel metrics.

Conversely, Henriksen (2016) investigated speech rhythm in highly proficient late bilinguals (L1-Spanish L2-English) and found out that their speech rhythm was constantly English-like; on the contrary, their speech rhythm in their native Spanish was not constantly native-like, which can be understood as a sign of language attrition.

Unlike the contribution of speech rhythm to global accent ratings, the relation between intonation and global accent has been investigated. Ulbrich & Mennen (2016) provide a thorough review and conclude that the importance of prosody in the perception of foreign accentedness is out of doubt; however, its relative contribution, as well as that of segments, is not conclusive. In their own investigation, it is concluded that both segments and intonation present important and independent effects on global accents, but the effect of segments was larger on the judgements.

In turn, Mennen (2004) investigated L1 and L2 intonation in five late bilinguals of Dutch and Greek. Four of her speakers not only failed to produce target-like intonation patterns, but also showed signs of attrition in their L1. Nonetheless, the author points out that the "speakers in this study did not develop a 'merged' system with compromise values between the L1 and L2 phones". Interestingly, the only speaker with native-like intonation in Greek was also the only one not to deviate from Dutch monolingual norm, which suggests not only a special linguistic (or intonational) aptitude, but also that L1 attrition is not necessary for L2 success. This goes in line with studies highlighting the role of language aptitude (Bylund et al., 2012; De Keyser, 2000).

Finally, it must be pointed out that all previously mentioned studies have in common that a specific feature is partially or totally transferred, but, as pointed out in Lleó (2017), "empty transfer" is also possible. According to this author, it consists "in not applying a certain phonological process or rule" as a result of the influence from one of the languages of the bilingual speaker. Specifically, she provides evidence for the allophonic distribution of stops and approximants /b d g/ and for nasal assimilation in Spanish (her data on children aged 7 show great variation for both aspects).

2.2.4 Concluding remarks on bilingual phonetics

After reviewing bilingual phonetic learnability and linguistic attrition across the lifespan (an also of delayed L1 acquisition in passing by), the major contribution of age of acquisition to the multifactorial phenomenon of bilingual acquisition is undeniable, whereas the impact of other factors is less obvious. It is unclear, however, whether age of acquisition is a good predictor of language success because of maturational constraints (as proposed by the CPH) or because of the lesser degree of linguistic entrenchment (as proposed in the Competing Model).

Interestingly, the "light" versions of these two theories are perfectly compatible. In its light version, there is no "critical" period, but a relatively wide period during which acquisition at native level is possible (but not guaranteed). Similarly, the light version of the Competing Model acknowledges that, apart from neuronal changes triggered by linguistic experience and practice, some changes in brain plasticity do take place.

There is solid evidence to support both the CPH and the CM. Evidence from delayed L1 acquisition confirms that humans are prepared for native-like L1 acquisition only for a limited time. To my knowledge, no critic of the CPH has argued convincedly why these maturational constraints should not apply too for L2 acquisition. Furthermore, the fact that no single late bilingual has been undisputable recognised as an exceptional leaner, i.e. with native-like pronunciation, reinforces the idea that some maturational changes do take place. The CPH however, fails to explain why pronunciation is more affected by these maturational changes than other linguistic aspects. There is even an expression to designate the phenomenon whereby somebody whose general L2 proficiency is noteworthy exhibits a marked foreign accent, the Joseph Conrad Phenomenon, but there is no expression to designate the opposite, i.e. somebody with a superb pronunciation, a very limited lexicon, and an L2 performance in grammar heavily influenced by the L1. The expression must be attributed to Scovel (1988: 65), according to Steinberg et al. (2001: 188).

On the contrary, the CM accounts very well for the differences in performance between pronunciation and other linguistic aspects by means of the different levels of linguistic entrenchment in the brain. Since the set of phonemes and intonational patterns we use is much more limited than the number of words we know, it is not surprising that they are more entrenched, because of their higher frequency of use. Beyond linguistic entrenchment, phonetics is also different from other linguistic aspects in that convergence can take place without necessarily convey extremely salient results. Whereas lexical transfer is very salient for the listener (e.g. bilingual speakers in Brazil use of *lembrieren* 'to remember', merging Portuguese *lembrar* 'to remember' and the German suffix -*ieren*; Fossile, 2010), phonetic convergence can be very subtle and gradual (e.g. VOT) that in many cases even falls within the ranges for monolingual norm. What is more, it can be so subtle that it should not be assumed that all differences between monolinguals and bilinguals are perceived, hence the pertinence of Abrahamsson & Hyltenstam's claim (2009) that linguistic scrutinies (acoustic studies in the context for pronunciation) are necessary to determine if the performance of bilingual speakers is fully comparable to that of monolinguals.

However, the CM fails to explain why ceasing to use the L1 does not lead to improved L2 performance. Indeed, in Bylund et al. (2012), the opposite was found, and positive ratings in the L1 were correlated with positive ratings in the L2. Besides, the light version of the CP also accepts that changes in brain plasticity are also partly responsible for the differences in linguistic outcomes.

Lastly, factors other than maturational constraints have been claimed to also play a role in bilingual linguistic acquisition, namely: type and amount of input, self-speech monitoring, linguistic aptitude and attitude, and language relatedness. As reviewed in 2.2.1.3 and 2.2.1.4 these variables undoubtedly shape to some extent the speakers' phonetic outcome, but they are far from being able to account global accent differences to the extent that age of acquisition does.

Besides, the importance of other factors is not constant across the lifespan. Because of the maturational constraints and/or the different levels if linguistic entrenchment, linguistic acquisition becomes more difficult as we grow older. In this context of increased difficulty, factors like language-relatedness, L1 & L2 use, linguistic aptitude, and attitude become gain considerable importance.

In sum, the existing evidence suggests that bilingual acquisition is multifactorial. Age of acquisition is the crucial factor, either as a result of brain changes, of linguistic entrenchment of both, but, nonetheless, other factors also come into play (especially, but not only, after puberty). Two facts support this claim. On the one hand, many early bilinguals have been documented not to perform native-like, which suggests that an early age of acquisition is crucial but not enough. On the other hand, factors other than age of acquisition usually correlate to some extent with post-puberty speakers' performance but not with that of early learners. The task of acquiring a native-like pronunciation becomes extremely complex in adulthood, as proves the fact that no adult speaker has been reported to pronounce native-like for several minutes or after acoustic scrutinies. Thus, it is no wonder that the best adult-speakers found in the literature were normally highly motivated, received extensive input, and seemingly had a high linguistic aptitude. On the contrary, no special characteristics are necessary among early bilinguals to develop a native-like accent, except for a minimum amount of exposure, which is yet to be quantified (Flege, 2007: 376).

Beyond identifying the factors responsible for the changes in global accent ratings, it is also interesting to investigate which specific phonetic features contribute to global accent. We have reviewed how bilinguals can differ from monolinguals in their production of segments, speech rhythm, and intonation, but we know little about the relative impact of each of these characteristics.

One of the relatively few investigations in that direction was carried out by Ulbrich & Mennen (2016), who conclude in their thorough summary that the evidence is inconclusive regarding whether intonation influences global accent ratings more than segmental production. In their own study with English (L2) - German (L1) bilinguals, the latter were found to have a stronger effect.

VOT was not significantly correlated with global accent in Lein et al. (2016). As noted in their literature review, this contrasts with Flege & Eefting (1987). In any case, none of those studies specifically tried to calculate the effect of VOT or vowels in global accent in relation to other sound categories or to intonation.

The group of Dutch proficient speakers of English in Flege & Eefting (1987) produced a 68.6 ms VOT for /t/, whereas the natives 90.4 ms, which turned out to be statistically significant, but more important than that is whether it is perceptually significant. There are good reasons to believe the opposite. To begin with, a closer look to the SD seems to indicate that a considerable number of the speakers actually fell within the bottom margins for native norm, which, needless to say, are as native-like as the upper margins. Secondly, the perception boundary for English /t vs d/ is placed, according to five native speakers in Flege & Eefting (1987), in 47 ms. The mean obtained in /t/ production by the proficient L2 speakers was 68.6 ms, which clearly exceeds the perceptual boundary. Similarly, Gabriel et al.'s (2018) early bilinguals produced German VOTs that deviated from monolingual norm but, again, a close look at the means and SDs seems to support the speculation that in most cases even with these means nothing odd would be detected in their VOT. After all, perception is more categorical than gradual and, as said before, bottom margins are as native-like as the upper margins of the monolingual norm. Lastly, Konopka & Pierrehumbert (2008) also reported minor differences in the quality of the vowels of their early bilinguals. These differences were not compared with ratings in foreign accent, but since most of their early bilinguals seem to have been born in the US, it is safe to assume that all of them are perceived as fully native-like despite these minor differences.

In addition, we also know that even speakers with no knowledge of the language tested can rate almost as accurately as native speakers of the language (Major, 2007). Thus, it seems sure to assert that there are universal L2 characteristics in pronunciation, perhaps less marked intonational patterns and/or a higher speech rate. These aspects are confirmed in Gut (2007).

In sum, the evidence is quite clear in that being bilingual affects the speakers' phonetic productions, both in their strongest language (Gabriel et al., 2018 & Konopka & Pierrehumbert, 2008) and in their weakest one (Ramon-Casas, 2011; Amengual & Chamoro, 2015). Yet, the question of how large these differences must be so that speakers are perceived to have a native or a foreign accent remains open due to the reduced amount of studies specifically addressing this point.

3. Empirical study

Two experiments with 40 participants were carried out during this research. A global accent task was performed for experiment 1, whereas experiment 2 consists of a series of acoustic analyses at the segmental level; additionally, the results of both experiments were sought for correlations with each other and the participants' linguistic profiles, sketched after a semi-structured interview.

Whereas experiment 1 allows us to determine the speakers who are perceived as native speakers in each language, experiment 2 and the statistical tests allow us to refine the answer by determining: a) whether those speakers are also comparable to monolinguals in phonetic terms, b) whether some speakers are similar or identical to monolinguals at segmental level and yet rated differently, and c) which sound classes affect nativeness judgements the most.

This procedure goes in line with Abrahamsson & Hyltenstam (2009), who claim that nativeness ratings must be validated by means of linguistic scrutinies (more details in 2.2.1) and with my own remarks against the sole use of short excerpts to determine nativeness (2.2.1 and 2.2.4).

For the purpose of this research and further works an oral corpus was compiled, from which a selection of materials was used in experiments 1 and 2. Since both the participants and the corpus for the two experiments are the same, these will be first described. Secondly, specific details of the methodology of each experiment will be provided, after which their results will be presented and briefly discussed. For all statistical tests, the significance level was set at 0.1 following Larson-Hall's (2010) recommendation for second language research. Lastly, a joint discussion will be provided at the end of this section.

3.1 Materials

Each participant completed four different tasks: the first one was a semi-structured interview in which the participants provided details about their linguistic profiles; secondly, a selection of words designed to measure Voice Onset Time was presented in written form and the speaker was required to utter the word; thereafter, a pseudo-spontaneous task served to obtain the bulk of the collected corpus; lastly, short excerpts of spontaneous speech were recorded. Each participant was recorded with either a Marantz PMD671 or a Marantz CDR310 professional sound recorder. All the recordings took place in quiet rooms at Hamburg or Kiel universities, except for the Spanish monolinguals, who were recorded in their own place or in a familiar environment in Spain (either in Madrid or in Illescas, a small city located in the province of Toledo and 35 km south of Madrid). Each session took around 45 minutes for monolingual speakers, and around one hour and a half for bilinguals.

3.1.1 Sociolinguistic questionnaire

It was presented in the form of an oral semi-structured interview and had a twofold objective. On the one hand, it served to verify that the participants met the linguistic requirements for the research; on the other, it was aimed to collect basic information beyond their linguistic profile (i.e. early bilingual, late bilingual or monolingual). The answers to different questions were then codified for statistical purposes on a chart (see "Bilingual speakers' sociolinguistic information" in the appendix) containing the following information:

I. speaker code: individual for each speaker; it consists of a combination of a code for each linguistic group and a personal number.
II. linguistic group: can be inferred from speaker code, those beginning with SMN are Spanish monolinguals; with GMN, German Monolinguals (GMN); with SLB, Spanish L1 late

bilinguals; with SEB, early bilinguals with Spanish as their societal language; lastly, GEB speakers are those early bilinguals whose societal language was German.

III. use of Spanish and German nowadays: extensive (at least 40% of their interactions) or limited (less than 40% of their interactions).

IV. use of Spanish and German during childhood: extensive or limited. When the participants had attended schools in which their heritage language was the main medium of instruction or when they spoke mostly or exclusively their heritage language at home, their heritage language use was coded as high. In cases in which the speakers limited their interactions in the heritage language to one progenitor at home and interactions with other speakers of the heritage language were rare, their heritage language use was classified as low.

V. identity (I): on a scale from 1 to 6, wherein 1 means "I feel only X (respective Spanish-speaking nationality)" and 6 "I feel only German".

VI. length of residence in Germany: counted in years and only asked to those whose societal language during childhood was Spanish.

VII. Spanish variety of reference: local dialect for SLB and SEBs and that of their progenitors for GEBs.

3.1.2 VOT task

Given the important differences in the realisation of stops and their high recurrence in both languages, a task was specially designed to measure Voice Onset Time in absolute initial position. Unlike earlier studies on VOT, all items were produced in isolation instead of within a carrier-sentence. This procedure was opted for because of the differences in VOT for both languages are bigger in absolute initial position than when preceded by an open syllable (see 2.1.2). Each word contained the target stop in stressed position followed by all five vowels in Spanish and by all long German vowels. It was important to control for both stress and vowel quality, since they have been reported to affect VOT (Lisker & Abramson, 1967, and Neary & Rochet, 1994, respectively). The target words can be consulted in the appendix.

3.1.3 Pseudo-spontaneous speech

This task aimed to imitate spontaneous speech at the same time that the phonetic context was strictly controlled for, hence its pseudo-spontaneous nature. Controlling phonetic contexts was essential for the sake of interspeaker comparability, however, a read-aloud task goes in detriment of those speakers who are used to speaking but not to reading in both languages. As a compromise formula, this task was designed with the aim of emulating natural speech at the same time than controlling for phonetic context.

In order to pursue this goal, two sets of materials with short dialogues or sentences were produced for each language (123 short sentences for the German set and 146 for the Spanish one). Some sentences consisted of a single word, but most of them contained between 2 and 6 words (only in few occasions slightly more than that).

Each sentence was unrelated to the preceding one and was presented in writing to the speaker in the form of a response to a previous statement introduced by the researcher that served to minimally contextualise the sentence, as in the following example:

> *Researcher: ¿Tú estás segura? 'Are you sure?'*
>
> *Participant:* ***Hazme caso, sé de lo que hablo 'Trust me, I know what I'm talking about'.***

These mini-dialogues were the most usual way to present the sentences to the participants, but occasionally the participants were presented a context, after which they had to utter their statement; for instance:

> *Researcher: Dein Mitbewohner behauptet, dass Saskia morgen kommt. Du weißt, dass das nicht stimmt und dass stattdessen Carsten kommt 'Your flatmate says that Saskia comes tomorrow. You know that it is Carsten who comes tomorrow'.*
>
> *Participant:* ***Nein, Carsten kommt morgen 'No, Carsten comes tomorrow'.***

The use of the same sentences guaranteed the control of phonetic contexts, whereas the emulation of spontaneous speech was pursued by instructing the participants to read silently their sentence as the researcher spoke, and then utter aloud that sentence without reading, looking at the researcher, and using the intonation they would employ in the same situation. The participants were encouraged to speak as naturally as they would do in their daily lives with friends or relatives and told that minor deviations in their sentences would be allowed. For example, they were encouraged to use the treatment form (and corresponding verb ending) typical from their region (*usted* or *vos* instead of *tú*). Similarly, if the participant was supposed to say *Hazme caso, sé de lo que hablo*, but said *Hazme caso, sé lo me digo* instead, no correction was made. Allowing such deviances has the disadvantage that the final set of sentences was not identical for all speakers but has the major advantage that most participants focused on producing a 'natural' speech in terms of intonation and speech rate, rather than on repeating literally the proposed sentences. Nonetheless, given the shortness of most items, most speakers rarely deviated from the proposed sentences, which resulted in an almost homogeneous corpus. A side effect of both the shortness of the sentences and of the fact of allowing minor deviances was that the participants just required a couple of seconds to memorise each sentence, leaving thus little room for planning careful and artificial pronunciations. A minority of speakers, however, read occasionally (especially in the longer sentences), in spite of the requirements to avoid it.

The complete Spanish and German sets can be consulted in the appendix. Around half of the Spanish sentences were taken (with minor or none modifications) from the intonation questionnaire designed for Central Peninsular Spanish in the Interactive Atlas of Spanish Intonation, which is accessible online[14]; the rest of the sentences were designed by the author (native Spanish speaker of that variety). The reason why part of the set was designed after the Interactive Atlas of Spanish intonation is that this research was originally conceived to investigate both segmental and suprasegmental characteristics; however, studying the impact of bilingualism on intonation requires a sine qua non condition, namely that bilinguals must have exactly the same intonation targets than the monolinguals of the control group. Unfortunately, it was only possible to recruit bilinguals who came from different regions of the Spanish-speaking world, which resulted in totally different reference patterns for intonation, which had to be excluded from the research. By contrast, the use of speakers of different regions for the study of the impact of bilingualism on segmental phonology is definitely not flawless, but possible and reasonable, given that differences in segmental phonology are not as marked as those in intonation. Additionally, they are much better described in the literature, which enables them to be controlled for.

In turn, the German set was freely adapted from the Spanish version by the researcher, proficient L2 German speaker, but all translations were revised by several German native speakers. Admitting the possibility that, no matter how many natives revise the translation, the translated version is probably vaguely less natural than the original one, it must nonetheless be signalled that using two sets with almost identical sentences in two languages had the advantage of facilitating the task to the participants. Since this task was time-consuming, the familiarity with the sentences when recording in the other language was an advantage to minimise tiredness. The order in which the two sets were gone through was decided by the participant.

3.1.4 Spontaneous speech

After the recording of the pseudo-spontaneous speech in each language, participants were required to 1) tell in detail what they had done during the testing day, 2) describe a sad event in their life, and 3) describe a merry memory. The participants were neither required nor impeded to retell the same events when performing this task in their second language.

3.2 Participants

75 participants were recorded for the elaboration of the corpus, however, only 40 were finally included in this research. The original sample of 75 speakers was not balanced, neither in terms of gender nor in terms of group membership. Many more women than men volunteered, as well as more monolinguals and late-bilinguals than early bilinguals, but for the statistical analyses, it is preferable to keep group sizes constant; additionally, there are important physiological differences between women and men that result in important phonetic differences, especially for vowels, but probably for fricatives too (Simpson

[14] http://prosodia.upf.edu/atlasentonacion/metodologia/index-english.html

& Ericsdotter, 2007, and Fuchs & Toda, 2010, to cite just an example for each sound class). All things considered, it was decided to limit the sample to 40 participants, who were divided into five groups of 8 members each: Spanish monolinguals (SMN), German monolinguals (GMN), L1 Spanish late bilinguals (SLB), early bilinguals raised in Spanish-speaking countries (SEB), and early bilinguals raised in Germany (GEB).

The monolingual groups were very homogeneous in their geographic origin. The Germans resided and were brought up in northern Germany; the vast majority in Schleswig-Holstein and Hamburg, but also in Niedersachsen, Nordrhein-Westfalen, Sachsen-Anhalt, and Berlin. Likewise, all Spanish monolinguals resided and spent their childhood in central Spain, namely in either the provinces of Madrid or Toledo. All monolingual speakers spoke no language at home other than that of their respective country.

The late bilinguals had been monolingually brought up in a Spanish-speaking country and arrived in Germany as adults; most of them speak the same variety of Spanish than the monolinguals and none of them had had relevant contact with non-northern varieties of German.

Lastly, all early bilinguals can be classified as simultaneous bilinguals, as they had acquired both languages since birth. Following Kupisch et al. (2014) and Kupisch & Lleó (2017), they were nonetheless differentiated in two groups according to their societal language. Thus, early bilinguals were divided into Spanish and German early bilinguals. All Spanish early bilinguals were brought up in different Spanish-speaking countries in families in which there was at least one native German progenitor, whereas German-dominant early bilinguals were brought up in Germany in families in which there was at least one native Spanish-speaking progenitor. The exact Spanish variety which bilinguals were exposed to can be consulted in the appendix (see "Bilingual speakers' sociolinguistic information"). At the time of the study, all of them were residing in Kiel or Hamburg.

These participants were mostly recruited through posts in social networks, namely in groups targeted to the Spanish-speaking community in Germany, such as *Españoles en Hamburgo*, *Chilenos en Hamburgo* etc.; only a few were contacted through word-of-mouth. German monolinguals were recruited in different ways: through announcements in the newsletters of the Department of Romance Languages at Hamburg University or in the Facebook group of the *Doktorandenkolleg* of the Hamburg University, through personal contacts, and via word-of-mouth. Lastly, Spanish monolinguals were recruited mostly through personal contacts and word-of-mouth.

The participation was fully altruist and the participants were aware that they would participate in a study on pronunciation but were not informed until the completion of the tasks what exactly was being investigated. Many reported believing that intonation was the research goal.

When first contacted, normally via email or social networks, the participants answered several questions in relation to their linguistic profile that served as screening out process. In the testing day, the participants also had to respond to a semi-structured interview that confirmed their assignment to a specific language group.

3.3 Experiment 1: global accent task.

3.3.1 Methodology

The speakers who participated in this task are the same 40 that were described in 3.2. In addition, 29 Spanish-speaking raters and 28 German raters participated in the research, whose geographical origin is distributed as follows. Spanish-speakers were of different nationalities: 15 Spaniards, 5 Chileans, 4 Colombians, 2 Ecuadorians, 1 Argentinean, 1 Costa Rican, and 1 Mexican. In turn, northern German speakers overwhelmingly prevailed among raters (all raters resided in northern Germany (in Hamburg or Schleswig-Holstein), but a few of them came from central and southern Germany. Their participation was also fully altruist and they were contacted through personal contacts and word-of-mouth.

Except for seven people, who resided in central Spain, all Spanish-speaking raters lived in northern Germany and had very different degrees of fluency in German, whereas the vast majority of German raters had little or no knowledge of Spanish at all. Ideally, the Spanish global accent would have taken place in different Spanish-speaking countries to ensure that the raters had no knowledge of German, but this would have implied spending notable time and monetary resources that in all likelihood do not compensate for the meagre advantages. The only study, to my knowledge, that has investigated language attrition for foreign accent perception is Major (2010). His findings describe a scenario in which ratings were virtually identical irrespective of listener group. Furthermore, the small differences found are hypothesised to possibly be a result of different degrees of contact with speakers of other dialects, rather than of attrition in language perception. Thus, those differences between Spanish-speaking and German raters probably had very little effect or none.

The task itself consisted in presenting a selection of the recorded material to a panel of native speakers in order to obtain nativeness judgements. Before recording the material, the participants were informed that excerpts of their recordings would be used in an anonymous global accent task but were not aware of the specific sentences that would be used so that they could not attempt to utter those sentences particularly carefully.

The selection for each language was roughly 20-30 seconds long and included six words from the VOT task, six sentences from the semi-spontaneous speech task, and one from the free speech task. The words from the VOT task and the semi-spontaneous sentences were the same for all participants. In the very few cases in which the participant had committed a grammatical error in one of these sentences, the sentence was discarded. Likewise, only error-free sentences were chosen from the free speech task to ensure that the nativeness judgments could only be attributed to global accent.

The German selection contained the following words from the VOT task: *Bohrer* ‘drill’, *pöbeln* ‘to swear’, *Dusche* ‘shower’, *These* ‘thesis’, *kühlen* ‘to cool’, and *Gabel* ‘fork’. Additionally, the following sentences were included:

> *Guten Tag. Ich möchte ein Kilo Zitronen.* ‘Good morning. I’d like one kilo of lemons.’
> *Was würdet ihr ohne mich machen?!* ‘What would you do without me?!’
> *Rita, als Bürgermeisterin?* ‘Rita, for mayor?’
> *Guck mal, die Sonne ist rausgekommen.* ‘Look, the sun has come out’
> *Ja. Ich hab Kopfschmerzen und mir ist schlecht.* ‘Yeah, I’ve got a headache and I don’t feel really well.’
> *Toll. Du bist ein Genie.* ‘Great. You’re a genius.’

The Spanish selection contained the following words from task 1: *bollo* ‘sweet roll’, *pecho* ‘chest’, *turno* ‘turn’, *disco* ‘disc’, *cura* ‘priest’, and *gusto* ‘taste’. Additionally, the following sentences from task 2 were included:

> *¿Julio? ¿Se presenta a alcalde?* ‘Julio? He’s running for mayor?’
> *Hazlo ya, ¡por favor! ¡Que se va a hacer tarde!* ‘Do it now, please! It’s getting late!’
> *Nada, es solo una pequeña infección.* ‘Nothing, it’s just a little infection’.
> *Puede que no le guste el regalo que le he comprado.* ‘He might not like the present I got him.’
> *¡Sí, mujer, de Guillermo! ¡¡De quién va a ser!!* ‘Come on, girl, from Guillermo. From whom else would it be?’
> *Hola, soy yo otra vez. ¿Ya ha llegado María?* ‘Hi, that’s me again. Has Maria already arrived?’

As noted in 3.1, both the Spanish and German sentences were responses to previous sentences that helped contextualise them. The sentences were selected so that virtually all sounds that would be acoustically measured were included. Besides, the Spanish set offers several opportunities for syllabic contraction (e.g. *ya ha* pronounced with only a vowel), and the German one offers several opportunities for glottal stop (e.g. before *ohne*). Furthermore, different intonation patterns are present in each set.

Group sessions were organised so that several participants listened to the recordings together in a quiet environment and through good quality equipment without headphones. Given that some of the speakers and raters were students at those universities, the raters were instructed to signal the participants acquainted to them (only one participant was identified by two raters) in order to discard these answers. During the group sessions, the raters were instructed to fill in the response sheet right after listening to the recording. They were told that they were required to carry out several tasks. The first one consisted in recognising whether the speakers were native or not; four possible answers were available to them: 1) "This person is definitely native", 2) "I believe this person is native", 3) "I believe this person is not native", and 4) "this person is definitely not native".

If they marked either option 1 or 2, they had to identify the country and region of the speakers and whether they had university studies or not. On the contrary, if they believed a speaker was not native, they had to ignore those questions and evaluate the accent of that person, for which they also had four possible answers: 1) "Even though s/he is not native, the accent is very good", 2) "Even though s/he is not native, the accent is good", 3) "This person is not native, and the accent is bad"; and 4) "This person is not native, and the accent is very bad". Questions regarding the country and region of origin, as well the level of instruction were finally not analysed in this investigation.

3.3.2 Results

As can be seen in table 20, monolingual means are closer to 1 (=undoubtedly native) than those of the bilinguals. For the bilingual groups, the difference between their societal language during childhood and their other language was computed (column Str-Weak Dif.). As expected, the late bilinguals are more unbalanced than the early bilinguals. In turn, the SEBs are less unbalanced than the GEBs, probably as a result of currently residing in Germany (their weakest language in terms of input during childhood).

	Sp. Mean (SD)	**Ger. (SD)**	**S-O**
SMN	1.32 (0.17)	- -	- -
SLB	1.69 (0.70)	3.72 (0.27)	-2.03
SEB	1.77 (0.47)	2.53 (1.19)	-0.76
GEB	2.30 (0.72)	1.25 (0.21)	-1.05
GMN	- -	1.12 (0.66)	- -

Table 20: global accent group means and standard deviations.

A battery of two-tailed Mann-Whitney tests yielded the following results. The SMNs did not differ significantly from SLBs (p = .293), but they did from the SEBs (p = .036) and the GEBs (.001); whereas the GMNs differed from the SEBs (p = .001) and the SLBs (p = .001) but not from the GEBs (p = .156). It must be noted that these data are not entirely comparable, since the SEBs are residing in Germany at the time of testing and two speakers probably had suffered attrition and; furthermore, the Spanish-speaking raters had to rate diatopic varieties other than their own, whereas the German raters and speakers were much more homogeneous.

Since the raters' dialectal background presumably affected their judgements, three different means were calculated for Spanish: one in which all speakers were included (Spanish Mean), one counting only the ratings of the Castilian speakers (Cast. Mean), and one counting the judgements of raters of Spanish-American varieties (Am. Mean).

	Sp. Mean	Am. Mean	Cast. Mean
SMN	1.32	1.62	1.03
SLB	1.69	1.86	1.53
SEB	1.77	1.85	1.68
GEB	2.3	2.48	2.12

Table 21: Spanish global accent means according to raters' dialectal background.

As can be seen, American speakers generally bestowed lower ratings to all groups of speakers, although the difference with Spanish Mean is higher for the monolingual group, which is composed exclusively by Castilian speakers. Similarly, the group of late bilinguals, in which speakers with Castilian background predominate, also receives a better rating by part of the Castilian raters. On the contrary, surprisingly, SEB speakers receive better ratings from Castilian speakers than from American ones although all of them are speakers of American varieties. Lastly, as expected given their dialectal background, GEB speakers receive better ratings from the American raters than from their Castilian ones. Notwithstanding, the dialectal background of the speakers do not alter the means to the point of leading to changes in the above-mentioned categories. Therefore, only the Spanish mean, i.e. with all raters, will be considered for the analyses of individual data. As reflected in table 22, when monolinguals are judged by peers of their same dialect or a very close variety, they are constantly classified as natives without any doubts whatsoever (means very close to 1, the maximum possible). By contrast, those Castilian speakers were also generally thought to be natives when evaluated by American raters, but the degree of certainty decreased.

	Sp. Mean	Am. Mean	Cast. Mean		Ger. Mean
SMN03	1.38	1.79	1	**GMN02**	1.14
SMN07	1.14	1.29	1	**GMN03**	1.21
SMN08	1.62	2.07	1.2	**GMN07**	1.18
SMN10	1.43	1.86	1	**GMN10**	1.04
SMN11	1.14	1.29	1	**GMN11**	1.14
SMN14	1.45	1.93	1	**GMN12**	1.08
SMN15	1.19	1.29	1.08	**GMN13**	1.15
SMN16	1.24	1.5	1	**GMN18**	1.04

Table 22: monolinguals' individual means for Spanish and German global accent.

	Ger. Mean	Sp. Mean	Am. Mean	Cast. Mean	S-HL (SP)	S-HL (AM)	S-HL (CA)
SLB01	4	1.07	1.14	1	-2.93	-2.86	-3
SLB04	3.18	1.34	1.57	1.13	-1.84	-1.61	-2.05
SLB05	3.71	3.29	3.31	3.27	-0.42	-0.4	-0.44
SLB06	3.89	1.79	2.21	1.4	-2.1	-1.68	-2.49
SLB09	3.68	1.54	2	1.07	-2.14	-1.68	-2.61
SLB13	4	1.1	1.21	1	-2.9	-2.79	-3
SLB16	3.54	1.61	2	1.27	-1.93	-1.54	-2.27
SLB18	3.79	1.76	1.43	2.07	-2.03	-2.36	-1.72

Table 23: SLBs' individual means for Spanish and German global accent.

	Ger. Mean	Sp. Mean	Am. Mean	Cast. Mean	S-HL (SP)	S-HL (AM)	S-HL (CA)
SEB01	1.79	2.38	2.57	2.2	0.59	0.78	0.41
SEB02	1.29	1.48	1.5	1.47	0.19	0.21	0.18
SEB03	1.43	2.39	2.62	2.2	0.96	1.19	0.77
SEB04	1.32	1.41	1.5	1.33	0.09	0.18	0.01
SEB05	4	1.41	1	1.73	-2.59	-3	-2.27
SEB06	3.36	1.21	1.36	1.07	-2.15	-2	-2.29
SEB07	3.89	1.72	1.86	1.6	-2.17	-2.03	-2.29
SEB08	3.21	2.14	2.43	1.87	-1.07	-0.78	-1.34

Table 24: SEBs' individual means for Spanish and German global accent.

	Ger. Mean	Sp. Mean	Am. Mean	Cast. Mean	S-HL (SP)	S-HL (AM)	S-HL (CA)
GEB02	1.18	3.79	4	3.6	-2.61	-2.82	-2.42
GEB03	1	1.59	1.71	1.47	-0.59	-0.71	-0.47
GEB04	1.67	2.59	3.07	2.13	-0.92	-1.4	-0.46
GEB05	1.32	2.38	2.5	2.27	-1.06	-1.18	-0.95
GEB07	1.19	2	2.29	1.73	-0.81	-1.1	-0.54
GEB08	1.39	2.59	2.57	2.6	-1.2	-1.18	-1.21
GEB09	1.11	1.62	1.64	1.6	-0.51	-0.53	-0.49
GEB10	1.15	1.83	2.07	1.6	-0.68	-0.92	-0.45

Table 25: GEBs' individual means for Spanish and German global accent.

Tables 23-25 present the individual data of all bilingual speakers in each language; SP and GM refer to Spanish and German means, whereas S-HL is the difference between their societal language during the childhood and their heritage language. The colours on the tables correspond to each of the options available to raters, who gave a numerical number to each speaker corresponding to the following values: 1) "This person is definitely native", 2) "I believe this person is native", 3) "I believe this person is not native", and 4) "this person is definitely not native". Consequently, means falling between 1 and 1.75 appear in dark green, between 1.76 and 2.5 in pale green, between 2.51 and 3.25 in pale red, and between 3.26 and 4 in dark red.

As can be seen, 9 out of 16 early bilingual speakers were rated to have a native pronunciation in both languages, namely: SEB01, SEB02, SEB03, SEB04, GEB03, GEB05, GEB07, GEB09, and GEB10. Among late bilinguals, no one was even close to it. The best score for German among them was 3.18.

These results go in line with the findings reviewed in 2.2.1. On the one hand, all late bilinguals were perceived as non-native speakers of German. Many of the speakers, despite being highly proficient in German, have even a mean of 4 or very close to it. On the other hand, as noted in Abrahamsson & Hyltenstam (2009), acquiring a language before puberty or even since birth like these early bilinguals is no guarantee of native-like performance, indeed, only roughly half of the speakers in this sample attained scores within the native range in their heritage language.

Especially worth noting is the case of speaker SEB04, who not only passed for native in both languages, but whose means are virtually identical (1.32 in German and 1.33 when rated by Spanish speakers - she comes from the Canary Islands). This speaker undoubtedly classifies as ambilingual for this task, i.e. she has equal command of pronunciation in both languages. It is even more astonishing if it is considered that SEB04 had lived in Germany only for six months at the time of testing. She reported extensive input and use of German during childhood in addition to Spanish, her societal language.

Without leaving the group of Spanish early bilinguals, it is worth noting the case of speaker SEB02. Her performance is also remarkably balanced across languages and, perhaps, could be also considered as ambilingual, albeit not *stricto sensu*.

The remaining speakers who can pass for natives in both languages, however, are clearly unbalanced in favour of one language, which one could expect to be their societal language during childhood. That is, indeed, the case for GEB03, GEB05, GEB07, GEB09, and GEB10, but speakers SEB01, SEB02, and SEB03 scored better in German, their current societal language and heritage language during childhood, than in Spanish. This seemingly shows that language dominance can change among early bilinguals over time. Moreover, speakers SEB01 and SEB03 present some signs of language attrition in Spanish. Spaniards rated them within the native range, although with a low certainty degree, and Americans classified them as non-natives. By contrast, the speech of speaker SLB05 is clearly attrited, since she was rated as clearly non-native, with even lower ratings than some early bilinguals brought up in Germany. Nonetheless, her Spanish is better rated than her German.

In 2.2.1, the impact on L2 pronunciation of different aspects was reviewed; in this sample, it is possible to study the impact of length of residence and cultural affiliation (which is to some extent related with a positive language attitude). Neither yielded significant correlations with mean German score on nativeness for the SLB group (Pearson correlations, one-tailed: p = .293 and p = .373); for the other groups, these correlations were not calculated, since there were differences in language use.

Furthermore, no correlation was found in any of the bilingual groups between the Spanish and German scores (Pearson correlations, two-tailed: p = .838, SLB; p = .478, SEB; and p = .354, GEB).

As explained in the methodology of this task (3.3.1), when the raters classified the speakers as probably or undoubtedly non-native, they were further required to value the quality of the non-native accent using also a four graded scale in which 1 was the highest score. This second step was necessary for the late bilinguals, since it was expected that all or most speakers would be perceived as non-native speakers and carrying out no further procedure would mask differences in their pronunciations (two speakers can be clearly perceived as non-natives, and yet the qualities of their accents may differ to a great extent).

SLB01	2.58	SLB05	1.79	SLB09	2.11	SLB16	1.50
SLB04	1.44	SLB06	1.86	SLB13	2.15	SLB18	1.96

Table 26: quality of non-native German accent among SLBs.

As can be seen, all these proficient speakers, who had been claimed to be undoubtedly non-native speakers of German, were judged to have either very good or good accents. Furthermore, the quality of their non-native German accent did not correlate with their mean Spanish score on nativeness (Pearson correlation, two-tailed: p = .436), neither with identity (p = .900) nor length of residence in Germany (p = .963).

3.4 Experiment 2: acoustic analyses.

All sentences used for the acoustic analyses were selected from the corpus with pseudo-spontaneous sentences (see 3.1.3). Additionally, the sentences and segments analysed for each sound class can be consulted in the appendix. Further methodological details are specific of each sound class and will be described in their respective section (see 3.4.1, vowels; 3.4.2, stops, 3.4.3, fricatives; and 3.4.4, rhotics).

3.4.1 Vowels

3.4.1.1 Methodology

The study of monolinguals' and bilinguals' vowel productions had a twofold goal. On the one hand, it aimed to provide a description of the vowel systems of each group. On the other, it sought to investigate whether the phonetic realisations of each bilingual group were comparable to those of the monolingual groups.

For so doing, it was necessary to normalise the data in order to deal with the fact that each person has a different vocal tract, whose size and shape varies from individual to individual. These anatomical differences provoke different resonances even if tongue movements are (nearly) identical and, consequently, the sound class of vowels presents vast interspeaker variability.

Among all well-known normalisation processes, Neary1 was chosen because, as noted in Thomas & Kendall (2007), it allows including the third formant (F3), which is essential for German, as F3 is the acoustic correlate of labialisation and this language presents pairs of homorganic vowels distinguished by means of [± rounded]. Other commonly employed normalisation methods, such as Labov, also implement F3 values, however, Thomas & Kendall (2007) note that it best performs with extraordinary large samples. These authors also note that the best performance of Neary1 is achieved when the entire vowel system is included, and they generally do not recommend scaling data, i.e. converting the normalised data into results expressed in Hertz, unless "you have submitted all of the speakers you are comparing to NORM at the same time". Following them, the entire vowel system and all speakers were simultaneously entered into the online tool for vowel normalisation (Thomas & Kendall, 2007). Once all data were normalised and scaled into Hertz, mean values were calculated for each group and individual.

All vowels were manually segmented and then the first three formants were extracted by means of a Praat script which takes measurements at midpoints (Kawahara, 2010). Inasmuch as neither syllable weight nor adjacent consonant segments could be controlled for across vocalic measurements, choosing the midpoint was necessary to minimise coarticulatory effects. Additionally, duration measurements were also taken by means of a Praat script developed by Buchholz (2016). In this regard, it is important to note that duration measurements cannot be used for across-vowels comparisons because of the different syllable structures; however, group comparisons are possible given that they are identical for all speakers. Lastly, all German vowels were measured four times per phoneme in stressed position (except for /ə/ and /ɐ/, which are always unstressed), whereas Spanish vowels were measured eight times per phoneme, four in stressed and four unstressed position.

3.4.1.2 Results

3.4.1.2.1 Spanish vowels

Table 27 presents both data on stressed and unstressed position, as well as the increases or decreases (expressed in %) for the latter in relation to the former.

Neary1 normalised Spanish vowels (scaled)									
Group	Vowel	F1	F2	Vowel	F1	F2	uns. vs str.	F1	F2
SMN	a-str	546	1426	a-uns	521	1388	SMN	-5	-3
SLB	a-str	550	1445	a-uns	506	1441	SLB	-8	0
SEB	a-str	554	1436	a-uns	512	1470	SEB	-8	2
GEB	a-str	564	1460	a-uns	514	1487	GEB	-9	2
SMN	e-str	418	1733	e-uns	417	1611	SMN	0	-7
SLB	e-str	440	1736	e-uns	414	1631	SLB	-6	-6
SEB	e-str	415	1767	e-uns	412	1638	SEB	-1	-7
GEB	e-str	428	1779	e-uns	407	1687	GEB	-5	-5
SMN	i-str	345	1904	i-uns	353	1830	SMN	2	-4
SLB	i-str	352	1901	i-uns	354	1750	SLB	1	-8
SEB	i-str	341	1910	i-uns	351	1849	SEB	3	-3
GEB	i-str	342	1893	i-uns	354	1848	GEB	3	-2
SMN	o-str	437	1180	o-uns	390	1250	SMN	-11	6
SLB	o-str	436	1187	o-uns	384	1188	SLB	-12	0
SEB	o-str	454	1174	o-uns	396	1244	SEB	-13	6
GEB	o-str	439	1145	o-uns	391	1228	GEB	-11	7
SMN	u-str	362	1185	u-uns	355	1212	SMN	-2	2
SLB	u-str	362	1160	u-uns	354	1225	SLB	-2	6
SEB	u-str	358	1114	u-uns	354	1205	SEB	-1	8
GEB	u-str	360	1165	u-uns	353	1165	GEB	-2	0

Table 27: group means for Spanish vowels (normalised and scaled after Neary1).

Each formant for each vowel in both stressed and unstressed position produced by each bilingual group was statistically compared with those of the monolinguals, which resulted in a series of 30 Mann-Whitney tests. The vast majority of tests did not reach significance, except for the following: SMN vs SLB: e-str-F1(.015), a-uns-F2 (.038), i-uns-F2 (.050), and o-uns-F2 (.028); SMN vs SEB: i-str-F3 (.083), u-str-F2 (.010), a-uns-F2 (.010); and SMN vs GEB: a-uns-F2 (.0002), e-uns F2 (.005).

In addition to the small number of differences found, it is worth highlighting that no single vowel, neither in stressed nor unstressed position, differs in both F1 and F2 simultaneously, which indicates that the data are mostly homogeneous across groups in spite of dealing with a sound class very sensitive to individual differences.

Remarkably, the SLBs presents more deviations from monolingual than SEBs and GEBs, despite sharing the same dialectal background with the monolinguals. Besides, GEBs and SMNs are virtually identical, which is somewhat surprising because Spanish vowels present wide ranges for formant structure, whereas German has narrow ranges as a result of its complex vowel system.

Additionally, two more aspects were investigated: whether bilinguals presented a tendency towards more centralised vowels in unstressed position and whether they produced longer vowels than monolinguals. When all vowels are averaged, GEB speakers present indeed a higher difference between stressed and unstressed position. For these speakers, mean average vowel duration is 26% shorter in unstressed position, whereas for SMN only 12%; in between fall SLBs (16%) and SEBs (21%). However, because of the important dialectal differences regarding vowel length (see 2.1.1.2.4), it is more likely that these differences are not the result of bilingualism, but a reflex of the difference Spanish varieties spoken by each group. As for a presumable tendency towards more centralised vowels, no conclusive evidence was found. Had bilinguals such tendency, they should present greater F1 decreases for /a/ and greater F2 increases for /i/ and /u/ as well as greater F2 decreases for /i/ and /e/ and greater increases for /u/ and /o/; however, the pattern is far from consistent and differences seem negligible. Lastly, distances between neighbouring phonemes in terms of F1 and F2 were calculated for each group.

Group	Vowel	F1%	F2%	Group	Vowel	F1%	F2%
SMN	e vs a	-23	22	SMN	u vs o	-17	1
SLB	e vs a	-25	23	SLB	u vs o	-21	-5
SEB	e vs a	-20	20	SEB	u vs o	-17	-2
GEB	e vs a	-24	22	GEB	u vs o	-18	2
Group	Vowel	F1%	F2%	Group	Vowel	F1%	F2%
SMN	i vs e	-17	10	SMN	o vs a	-20	-17
SLB	i vs e	-18	8	SLB	o vs a	-18	-18
SEB	i vs e	-20	10	SEB	o vs a	-20	-18
GEB	i vs e	-20	7	GEB	o vs a	-22	-21

Table 28: F1 and F2 distances among neighbouring phonemes in Spanish at group level.

As can be seen in table 28, the distances are remarkably constant across groups, which reinforces the claim that there is no relevant difference in vocalic productions among bilinguals and SMNs.

These same distances were calculated at the individual level. For F1, the minimum contrast produced by a Spanish monolingual was of 11% and the maximum of 29%. Only four cases were detected in which a smaller distance was kept in terms of F1 (GEB03 for /u/ vs /o/, and SLB06, GEB07, and SEB02 for /o/ vs /a/). These three speakers have an /o/ phoneme more open than typical for monolinguals in Spanish, whereas the tongue presents a higher position for GEB03 in her /o/ productions. Nonetheless, the combination of both F1 and F2 seemingly guarantees robust phonemic contrasts for these four speakers.

Speaker	Vowel	F1%	F2%	Speaker	Vowel	F1%	F2%
SMN03	e vs a	-21	26	SLB01	e vs a	-19	38
SMN07	e vs a	-25	25	SLB04	e vs a	-19	23
SMN08	e vs a	-24	23	SLB05	e vs a	-22	27
SMN10	e vs a	-23	26	SLB06	e vs a	-17	15
SMN11	e vs a	-21	15	SLB09	e vs a	-15	13
SMN14	e vs a	-19	16	SLB13	e vs a	-26	15
SMN15	e vs a	-27	21	SLB16	e vs a	-20	15
SMN16	e vs a	-26	21	SLB18	e vs a	-22	19
SEB01	e vs a	-18	25	GEB02	e vs a	-26	19
SEB02	e vs a	-19	11	GEB03	e vs a	-17	19
SEB03	e vs a	-25	28	GEB04	e vs a	-24	25
SEB04	e vs a	-26	22	GEB05	e vs a	-19	25
SEB05	e vs a	-29	14	GEB07	e vs a	-24	27
SEB06	e vs a	-27	26	GEB08	e vs a	-30	20
SEB07	e vs a	-26	31	GEB09	e vs a	-26	23
SEB08	e vs a	-29	28	GEB10	e vs a	-27	17

Table 29: individual phonemic distance for Spanish /e/ vs /a/.

Speaker	Vowel	F1%	F2%	Speaker	Vowel	F1%	F2%
SMN03	i vs e	-12	19	SLB01	i vs e	-15	7
SMN07	i vs e	-20	3	SLB04	i vs e	-22	10
SMN08	i vs e	-13	15	SLB05	i vs e	-27	-3
SMN10	i vs e	-18	11	SLB06	i vs e	-17	11
SMN11	i vs e	-25	-3	SLB09	i vs e	-21	13
SMN14	i vs e	-17	20	SLB13	i vs e	-17	7
SMN15	i vs e	-18	4	SLB16	i vs e	-14	16
SMN16	i vs e	-16	12	SLB18	i vs e	-26	15
SEB01	i vs e	-22	10	GEB02	i vs e	-20	15
SEB02	i vs e	-17	20	GEB03	i vs e	-20	17
SEB03	i vs e	-17	-3	GEB04	i vs e	-21	-14
SEB04	i vs e	-18	-2	GEB05	i vs e	-19	7
SEB05	i vs e	-19	13	GEB07	i vs e	-13	17
SEB06	i vs e	-15	7	GEB08	i vs e	-19	-7
SEB07	i vs e	-19	14	GEB09	i vs e	-24	8
SEB08	i vs e	-14	9	GEB10	i vs e	-22	10

Table 30: individual phonemic distance for Spanish /i/ vs /e/.

Speaker	Vowel	F1%	F2%	Speaker	Vowel	F1%	F2%
SMN03	u vs o	-23	-5	SLB01	u vs o	-19	-5
SMN07	u vs o	-18	-7	SLB04	u vs o	-16	-6
SMN08	u vs o	-11	0	SLB05	u vs o	-21	-2
SMN10	u vs o	-12	1	SLB06	u vs o	-24	-5
SMN11	u vs o	-15	9	SLB09	u vs o	-15	-5
SMN14	u vs o	-21	0	SLB13	u vs o	-14	-5
SMN15	u vs o	-20	3	SLB16	u vs o	-12	-1
SMN16	u vs o	-16	1	SLB18	u vs o	-12	13
SEB01	u vs o	-24	-2	GEB02	u vs o	-10	18
SEB02	u vs o	-28	-11	GEB03	u vs o	-8	27
SEB03	u vs o	-26	-3	GEB04	u vs o	-24	-7
SEB04	u vs o	-18	-8	GEB05	u vs o	-23	-8
SEB05	u vs o	-21	-4	GEB07	u vs o	-27	-6
SEB06	u vs o	-19	-2	GEB08	u vs o	-20	-5
SEB07	u vs o	-20	-8	GEB09	u vs o	-13	-3
SEB08	u vs o	-15	-4	GEB10	u vs o	-16	3

Table 31: individual phonemic distance for Spanish /u/ vs /o/.

Speaker	Vowel	F1%	F2%	Speaker	Vowel	F1%	F2%
SMN03	o vs a	-13	-10	SLB01	o vs a	-19	-9
SMN07	o vs a	-22	-16	SLB04	o vs a	-24	-21
SMN08	o vs a	-21	-16	SLB05	o vs a	-20	-21
SMN10	o vs a	-20	-19	SLB06	o vs a	-6	-12
SMN11	o vs a	-17	-19	SLB09	o vs a	-16	-17
SMN14	o vs a	-14	-14	SLB13	o vs a	-28	-18
SMN15	o vs a	-22	-24	SLB16	o vs a	-17	-18
SMN16	o vs a	-29	-18	SLB18	o vs a	-33	-26
SEB01	o vs a	-17	-13	GEB02	o vs a	-32	-28
SEB02	o vs a	-5	-19	GEB03	o vs a	-32	-27
SEB03	o vs a	-15	-21	GEB04	o vs a	-13	-12
SEB04	o vs a	-22	-20	GEB05	o vs a	-11	-17
SEB05	o vs a	-22	-20	GEB07	o vs a	-8	-11
SEB06	o vs a	-21	-20	GEB08	o vs a	-28	-25
SEB07	o vs a	-18	-12	GEB09	o vs a	-31	-23
SEB08	o vs a	-22	-20	GEB10	o vs a	-20	-28

Table 32: individual phonemic distance for Spanish /o/ vs /a/.

3.4.1.2.2 German Vowels

The acoustic data for each phoneme (tables 33-42) show that, unlike for Spanish vowels, there are important differences across groups for several German phonemes, which was confirmed by means of a battery of Mann-Whitney tests (two-tailed), one per vowel and formant, that compared the performance of each bilingual group with that of monolinguals. The significant differences will be reported separately for each phoneme given the complexity of the German vowel system. Additionally, Wilcoxon tests (two-tailed) were run in order to compare the tense vowel values of each group with those of their lax counterpart, i.e. to test statistically whether a phonemic contrast was kept.

		F1	F2	D			F1	F2	D		F1%	F2%	D%
GMN	aː	528	1454	147	GMN	a	505	1457	72	aːvs a	5	0	104
GEB	aː	527	1432	161	GEB	a	499	1483	79	aː vs a	6	-3	104
SEB	aː	529	1418	169	SEB	a	506	1437	84	aː vs a	5	-1	101
SLB	aː	513	1439	126	SLB	a	498	1462	85	aː vs a	3	-2	48

Table 33: duration, F1 and F2 for German /aː/ and /a/ and their relative changes.

The Mann-Whitney tests revealed that the only significant difference for /aː/ between monolinguals and SLBs, on the one hand, and SEBs, on the other, was in duration. Besides, SEBs also differed in duration for /a/.

It is also of interest that among German monolinguals the tongue occupies the same position on the horizontal axis in /a/ and /aː/, whereas height differences are minimal; indeed, the Wilcoxon test (two-tailed) comparing these two phonemes found no significance in formant structure among monolinguals. This confirms that these two vowels are solely distinguished by length in this northern variety of German (Kohler, [2]1995: 170; but see also 2.1.1.3.1). The Wilcoxon tests also revealed that there is no difference in formant structure for these phonemes among any of the bilingual groups, except for F1 among GEBs. On the contrary, duration differences were significative for all groups, but the duration contrast is clearly less robust for SLBs.

		F1	F2	D			F1	F2	D		F1%	F2%	D%
GMN	eː	364	1948	125	GMN	ɛ	427	1655	86	eː vs ɛ	-15	18	45
GEB	eː	368	1958	148	GEB	ɛ	433	1681	80	eː vs ɛ	-15	16	85
SEB	eː	356	1953	172	SEB	ɛ	421	1620	92	eː vs ɛ	-15	21	87
SLB	eː	415	1735	118	SLB	ɛ	410	1730	83	eː vs ɛ	1	0	42

Table 34: duration, F1 and F2 for German /eː/ and /ɛ/ and their relative changes.

Group comparisons revealed that SLBs clearly deviate from monolinguals for /eː/ and /ɛ/, namely in /ɛ/ F1, /eː/ F1, and /eː/ F2. In turn, SEBs and GEBs deviate from monolinguals in duration.

More importantly, SLBs' /ɛ/ and /eː/ realisations are virtually identical in formant structure (no significant difference was found in the Wilcoxon tests), which does not mean that the two phonemes have merged, as duration differences were significant. On the contrary, both duration and F1 and F2 differences reached significance for the other three groups reached significance. That is, whereas monolinguals differentiate these two phonemes by means of both formant structure and duration, the latter is the only means used by late bilinguals.

		F1	F2		F1	F2		F1%	F2%
GMN	ɛː	382	1892	eː	364	1948	eː vs ɛ	5	-3
GEB	ɛː	370	1933	eː	368	1958	eː vs ɛ	1	-1
SEB	ɛː	377	1865	eː	356	1953	eː vs ɛ	6	-5
SLB	ɛː	413	1698	eː	415	1735	eː vs ɛ	0	-2

Table 35: duration, F1 and F2 for German /ɛː/ and /eː/ and their relative changes.

German /ɛː/ is well-known to be absent in the speech of most northern speakers; indeed, this phoneme has merged with /eː/ for GMNs, GEBs, and SEBs. In the case of SLB, /ɛː/ is clearly more open, which goes in line with the findings for /ɛ/ and /eː/. The statistical tests for SLBs indeed showed significant differences with monolinguals for F1, F2, and duration.

		F1	F2	D			F1	F2	D		F1%	F2%	D%
GMN	øː	355	1466	108	GMN	œ	405	1566	64	øː vs œ	-12	-6	69
GEB	øː	349	1505	119	GEB	œ	430	1671	60	øː vs œ	-19	-10	98
SEB	øː	355	1543	115	SEB	œ	407	1561	59	øː vs œ	-13	-1	95
SLB	øː	368	1481	106	SLB	œ	386	1530	56	øː vs œ	-5	-3	89

Table 36: duration, F1 and F2 for German /øː/ and /œ/ and their relative changes.

A further consequence of the lack of formant contrast between /ɛ/ and /eː/ among SLBs is that they do not differentiate between /œ/ and /øː/ in terms of formant structure, which are the rounded counterparts of /ɛ/ and /eː/. Wilcoxon tests made that patent, since no difference in formant structure reached significance, whereas in the rest of the groups there were significant differences for two or even the three formants. However, the contrast is again preserved in terms of duration, as confirmed by the Wilcoxon test.

Furthermore, SLBs differed significantly from monolinguals in F1 for /œ/ and F2 for /øː/. Lastly, GEB speakers differed from monolinguals in both F2, and F3 for /œ/. Like for the rest of bilinguals, their F3 values indicate a lesser degree of lip-protrusion.

		F1	F2	D			F1	F2	D		F1%	F2%	D%
GMN	iː	329	1955	72	GMN	ɪ	381	1634	40	iː vs ɪ	-14	20	80
GEB	iː	334	1950	78	GEB	ɪ	383	1634	46	iː vs ɪ	-13	19	70
SEB	iː	328	1917	96	SEB	ɪ	385	1710	59	iː vs ɪ	-15	12	63
SLB	iː	344	1851	86	SLB	ɪ	358	1822	51	iː vs ɪ	-4	2	69

Table 37: duration (ms), F1 and F2 (Hz) for German /iː/ and /ɪ/ and relative changes.

Anew, SLBs have created two separate categories for the pair /ɪ/-/iː/ but solely differentiated by means of vowel length. As for formant structure, only F1 differed significantly in their productions of these two sounds, but a difference of -4% does not seem to be perceptually relevant. In contrast, the Wilcoxon tests proved that all three formants for these sounds differed among SEBs, GEBs, and GMNs.

As for group comparisons, SLBs differed from monolinguals significantly only for /ɪ/ in terms of F1 and F2, and for both /ɪ/ and /iː/ in duration. Although duration is the only means by which the two phonemes are contrasted in this group, their lengthening is shorter than that of GMNs.

In turn, in the SEB vs GMN comparison both F2 for /ɪ/ and duration differences for both phonemes were significant. The relative distances between /ɪ/ and /iː/ show that the phonemic contrast is slightly less robust in this group but still big enough.

		F1	F2	D			F1	F2	D		F1%	F2%	D%
GMN	yː	319	1709	123	GMN	ʏ	363	1470	98	yː vs ʏ	-12	16	25
GEB	yː	318	1717	128	GEB	ʏ	361	1457	104	yː vs ʏ	-12	18	23
SEB	yː	323	1745	134	SEB	ʏ	363	1508	111	yː vs ʏ	-11	16	21
SLB	yː	331	1667	117	SLB	ʏ	349	1424	83	yː vs ʏ	-5	17	40

Table 38: duration, F1 and F2 for German /yː/ and /ʏ/ and their relative changes.

Oddly enough, this rounded pair presents a partial distinction in formant structure in the group of SLBs that is not present in its unrounded counterpart (the first and second formants reached significance in the Wilcoxon tests for this group). The relative changes for F1, nonetheless, seem too meagre to be compatible with a perceptible distinction. In any case, the F2 difference supports the contrast maintained by means of vowel length. Indeed, the contrast in vowel length is far greater in the late-bilingual group than in the monolingual control group, which resulted in a significant difference in the Mann-Whitney test for duration.

		F1	F2	D			F1	F2	D		F1%	F2%	D%
GMN	oː	355	1075	100	GMN	ɔ	432	1257	60	oː vs ɔ	-18	-14	67
GEB	oː	361	1057	116	GEB	ɔ	434	1265	65	oː vs ɔ	-17	-16	78
SEB	oː	368	1091	119	SEB	ɔ	427	1210	82	oː vs ɔ	-14	-10	45
SLB	oː	417	1231	88	SLB	ɔ	395	1212	72	oː vs ɔ	6	2	22

Table 39: duration, F1 and F2 for German /oː/ and /ɔ/ and their relative changes.

Formant differences between /ɔ/ and /oː/ reached significance for both F1 and F2 in the Wilcoxon tests for all groups except for SLB. In this group, only F1 differs significantly according to the test, but, again, the difference is probably too meagre to be perceived (6%). Thus, the contrast is seemingly maintained anew solely by means of vowel length, although it is unclear whether the relative difference of just 22% is gib enough in perceptual terms. By contrast, SEBs, GEBs, and GMN presented robust phonemic contrast according to the Wilcoxon tests.

In the Mann-Whitney tests, SLBs differed from German monolinguals for both vowels: for /ɔ/ in terms of duration and F1, and from /oː/ in terms of F1 and F2. In turn, SEBs differed from monolinguals in duration and F2 for /ɔ/, whereas GEBs in duration for /oː/. However, whereas SEBs and GEBs produced longer vowels than the monolinguals, the SLBs produced shorter ones.

		F1	F2	D			F1	F2	D		F1%	F2%	D%
GMN	uː	341	1138	75	GMN	ʊ	364	1198	52	uː vs ʊ	-6	-5	44
GEB	uː	329	1038	82	GEB	ʊ	369	1228	45	uː vs ʊ	-11	-15	82
SEB	uː	337	1070	88	SEB	ʊ	375	1215	51	uː vs ʊ	-10	-12	73
SLB	uː	333	1164	70	SLB	ʊ	340	1205	42	uː vs ʊ	-2	-3	67

Table 40: duration, F1 and F2 for German /uː/ and /ʊ/ and their relative changes.

Differences in formant structure in the lax-tense pair /ʊ/ vs /uː/ are well kept in all groups except for, again, SLBs. Only F1 reached significance in the Wilcoxon test, but a -2% difference does undoubtedly not suffice perceptually. This group also differed in the Mann-Whitney tests from monolinguals in duration and F1 for /ʊ/, and in F1 for /uː/.

In turn, whilst there are no statistical differences between GMNs and SEBs, GEB speakers differed from GMNs in everything for /uː/. The relative phonemic distances indicate that the boundaries between /uː/ and /oː/ have become very fuzzy for GMNs, whereas are more robust for the bilinguals. To my knowledge, no change-in-progress has been yet reported indicating a possible phonological merge of /uː/ and /oː/ in northern Germany, nor the data reviewed in 2.1.1.3 indicate so. Thus, in this case, monolinguals might have produced anomalous /uː/ tokens and the differences between these two groups should not be attributed to an effect of GEB's bilingualism.

GMN	uː vs oː	-4	6	2
GEB	uː vs oː	-9	-2	-1
SEB	uː vs oː	-8	-2	0
SLB	uː vs oː	-20	-5	-2

Table 41: relative distances between German /uː vs oː/.

		F1	F2	D			F1	F2	D		F1%	F2%	D%
GMN	ɐ	465	1419	79	GMN	ə	360	1559	48	ɐ vs ə	29	-9	65
GEB	ɐ	465	1480	77	GEB	ə	372	1586	46	ɐ vs ə	25	-7	67
SEB	ɐ	447	1418	73	SEB	ə	379	1640	54	ɐ vs ə	18	-14	35
SLB	ɐ	435	1455	67	SLB	ə	383	1625	54	ɐ vs ə	14	-10	24

Table 42: duration, F1 and F2 for German /ɐ/ and /ə/ and their relative changes.

Regarding unstressed vowels, there is a slight phonetic difference between the SLB group and monolinguals. These two central vowels are amply differentiated in the monolingual group, whereas the contrast is somewhat less robust for the SLBs; nonetheless, the magnitude of the contrast does not hinder at all the distances between these two sounds. The Wilcoxon tests also supported this view, since F1 and F2 reached significance for this phonemic comparison in this group as well as among the other bilinguals and monolinguals.

Given the perceptual similarity with /a/, a comparison with this sound was also carried out in order to investigate whether /ɐ/ and /a/ have merged in the speech of bilinguals. As can be seen in table 43, not only this is not the case, but the contrast is actually better preserved in the speech of SEB and SLB speakers.

	Vowel	F1	F2	D	Vowel	F1	F2	D	Vowel	F1	F2	D
GMN	ɐ	465	1419	79	a	505	1457	72	ɐ vs a	-8	-3	10
GEB	ɐ	465	1480	77	a	499	1483	79	ɐ vs a	-7	0	-3
SEB	ɐ	447	1418	73	a	506	1437	84	ɐ vs a	-12	-1	-13
SLB	ɐ	435	1455	67	a	498	1462	85	ɐ vs a	-13	0	-21

Table 43: duration, F1 and F2 for German /ɐ/ and /a/.

Lastly, a global note on tense vs lax contrasts is illustrative. The distinction in duration between tense and lax vowels is very robust in all four groups (table 44), but the picture resembles much that of labialisation for the front rounded phonemes, i.e. the feature is phonologically acquired by all bilinguals, but, yet, the phonetic productions of SLB are shorter than that of GMNs. On the contrary, the two groups of early bilinguals have enlarged the contrast in duration.

This phoneme contrast is also kept by means of F1 and F2 changes. Since in the tense vs lax comparison F1 generally decreases, whilst F2 increases, both values were converted into absolute values, and the sum of both values is given in table 44; the value reflects combined formant variation.

	F1 %	F2 %	ABS_F1+F2 %	Dur_Dif %
GMN	-10	10	20	61
GEB	-12	7	19	76
SEB	-10	9	20	70
SLB	-1	8	9	51

Table 44: mean duration F1 and F2 relative changes of tense and lax German vowels per group.

To conclude with the analyses at group level, differences in the homorganic vowels solely distinguished by the feature [± rounded] will be reported. As expected, not only F3 decreases with lip-protrusion; indeed, F2 decreases to a larger extent across groups for the four pairs of homorganic rounded & unrounded vowels. Another tendency noted across groups is that between neighbouring vowels, the higher ones present more intense contrast. Thus, formant changes in /yː/ vs /iː/ are bigger than those in /ʏ/ vs /ɪ/; likewise, changes in /øː/ vs /eː/ are also bigger than those in /œ/ vs /ɛ/. Additionally, it is also remarkable that the two early bilinguals produced their /œ/ tokens with minimal or none lip-protrusion, but not the late bilinguals.

		F1	F2	F3			F1	F2	F3			F1	F2	F3
GMN	iː	329	1955	3103	GMN	yː	319	1709	2855	GMN	yː vs iː	-3	-13	-8
GEB	iː	334	1950	3124	GEB	yː	318	1717	2845	GEB	yː vs iː	-5	-12	-9
SEB	iː	328	1917	3101	SEB	yː	323	1745	2898	SEB	yː vs iː	-2	-9	-7
SLB	iː	344	1851	3074	SLB	yː	331	1667	2935	SLB	yː vs iː	-4	-10	-5

Table 45: absolute values and relative changes for /yː/ vs /iː/.

		F1	F2	F3			F1	F2	F3			F1	F2	F3
GMN	ɪ	381	1634	2993	GMN	ʏ	363	1470	2827	GMN	ʏ vs ɪ	-5	-10	-6
GEB	ɪ	383	1634	2985	GEB	ʏ	361	1457	2843	GEB	ʏ vs ɪ	-6	-11	-5
SEB	ɪ	385	1710	3006	SEB	ʏ	363	1508	2874	SEB	ʏ vs ɪ	-6	-12	-4
SLB	ɪ	358	1822	3015	SLB	ʏ	349	1424	2864	SLB	ʏ vs ɪ	-3	-22	-5

Table 46: absolute values and relative changes for /ʏ/ vs /ɪ/.

		F1	F2	F3			F1	F2	F3			F1	F2	F3
GMN	eː	364	1948	3044	GMN	øː	355	1466	2820	GMN	øː vs eː	-2	-25	-7
GEB	eː	368	1958	3072	GEB	øː	349	1505	2835	GEB	øː vs eː	-5	-23	-8
SEB	eː	356	1953	3081	SEB	øː	355	1543	2845	SEB	øː vs eː	0	-21	-8
SLB	eː	415	1735	3023	SLB	øː	368	1481	2878	SLB	øː vs eː	-11	-15	-5

Table 47: absolute values and relative changes for /øː/ vs /eː/.

		F1	F2	F3			F1	F2	F3			F1	F2	F3
GMN	ɛ	427	1655	2958	GMN	œ	405	1566	2868	GMN	œ vs ɛ	-5	-5	-3
GEB	ɛ	433	1681	2952	GEB	œ	430	1671	2951	GEB	œ vs ɛ	-1	-1	-0
SEB	ɛ	421	1620	2901	SEB	œ	407	1561	2915	SEB	œ vs ɛ	-3	-4	0
SLB	ɛ	410	1730	2991	SLB	œ	386	1530	2860	SLB	œ vs ɛ	-6	-12	-4

Table 48: absolute values and relative changes for /œ/ vs /ɛ/.

Table 49 reports mean differences in the first three formants averaged across the four homorganic pairs of rounded and unrounded vowels, and, as can be seen, the difference between monolinguals and bilinguals is negligible.

	F1	F2	F3
GMN	-4	-13	-6
GEB	-4	-12	-5
SEB	-3	-11	-5
SLB	-6	-14	-5

Table 49: relative changes for all rounded vowels vs their unrounded counterparts per groups.

In what follows, findings at individual level regarding tense vs lax contrast and lip-rounding will be reported but, given the large number of data, the individual acoustic data for each phoneme will not be included.

A close look at individual data reveals several relevant aspects. For the tense vs lax pairs, some German monolinguals present a very robust contrast involving F1, F2, and duration changes. Others, however, present minor or no changes in F1 and F2 or in duration. In order to decide which speakers phonologically discriminate between these tense vs lax pairs at monolingual level, it was decided that speakers needed to present either a contrast of at least 60% in terms of duration or that the combined F1&F2 variation should reach at least 20%, since those two values represent the means for the monolingual control group (table 44).

Thus, three profiles emerge from this procedure: those who produce a clear contrast in both combined F1&F2 variation and duration, those who produce a robust contrast in only one of the two parameters, and those who produce no robust contrast at all. In the following tables, individual means over 60% (duration) and 20% (combined F1%F2 variation) are in **bold letters.**

aː vs a	**ABS_F1+F2**	**DUR**	**aː vs a**	**ABS_F1+F2**	**DUR**	**eː vs ɛ**	**ABS_F1+F2**	**DUR**	**eː vs ɛ**	**ABS_F1+F2**	**DUR**
GMN02	9	**148**	GEB02	1	**80**	GMN02	**23**	**80**	GEB02	**35**	**120**
GMN03	15	**93**	GEB03	11	**112**	GMN03	**34**	30	GEB03	**30**	**63**
GMN07	10	**102**	GEB04	12	**83**	GMN07	**30**	46	GEB04	**22**	39
GMN10	10	59	GEB05	11	**111**	GMN10	**60**	36	GEB05	**25**	**67**
GMN11	**23**	**133**	GEB07	10	**148**	GMN11	**40**	**62**	GEB07	19	**65**
GMN12	**37**	**152**	GEB08	6	**76**	GMN12	**26**	37	GEB08	**49**	**191**
GMN13	10	**129**	GEB09	16	**148**	GMN13	18	23	GEB09	**38**	**88**
GMN18	6	45	GEB10	13	**110**	GMN18	**33**	53	GEB10	**35**	**68**
SEB01	2	**102**	SLB01	8	28	SEB01	**33**	15	SLB01	9	24
SEB02	13	**79**	SLB04	**20**	**134**	SEB02	**33**	**91**	SLB04	11	48
SEB03	15	53	SLB05	3	**76**	SEB03	**42**	**110**	SLB05	14	21
SEB04	4	**150**	SLB06	13	33	SEB04	**41**	**112**	SLB06	7	**82**
SEB05	5	**134**	SLB09	2	39	SEB05	18	**117**	SLB09	7	11
SEB06	6	**114**	SLB13	7	1	SEB06	**49**	**84**	SLB13	5	45
SEB07	**44**	**120**	SLB16	5	45	SEB07	**30**	**75**	SLB16	**20**	26
SEB08	18	**85**	SLB18	5	**72**	SEB08	**45**	**106**	SLB18	2	**86**

Table 50: individual phonemic contrasts (expressed in %) for German /a/ vs /a:/ and /e:/ vs /ɛ/.

As can be seen in table 50, only two monolinguals contrast tense /a:/ with lax /a/ in both combined F1&F2 and duration. All GEBs and SEBs contrast these two phonemes in a comparable way to monolinguals, except for SEB03. Lastly, four late bilinguals contrast between these two phonemes like monolinguals do. These findings go in line with the previous mention to vowel length as the primary phonetic cue for the opposition of this tense vs lax pair.

By contrast, for most monolinguals combined F1&F2 changes are very important to contrast /eː/ with /ɛ/. Interestingly, both most SEBs and GEBs present robust contrast in both measurements. Lastly, only three late bilinguals contrast in one of the two parameters to the same extent than monolinguals.

ø: vs œ	ABS_F1+F2	DUR	ø: vs œ	ABS_F1+F2	DUR	iː vs ɪ	ABS_F1+F2	DUR	iː vs ɪ	ABS_F1+F2	DUR
GMN02	**20**	**66**	GEB02	**29**	**64**	GMN02	**32**	**70**	GEB02	**38**	43
GMN03	**21**	**97**	GEB03	19	**89**	GMN03	**28**	42	GEB03	**24**	**100**
GMN07	**21**	**65**	GEB04	**23**	**65**	GMN07	**38**	**105**	GEB04	15	34
GMN10	**28**	45	GEB05	**35**	51	GMN10	**28**	**79**	GEB05	**38**	**86**
GMN11	**22**	**85**	GEB07	15	**155**	GMN11	**34**	**101**	GEB07	**42**	**98**
GMN12	15	**98**	GEB08	**25**	**255**	GMN12	**35**	**65**	GEB08	**30**	**62**
GMN13	5	**126**	GEB09	**44**	**101**	GMN13	**33**	**97**	GEB09	**45**	**104**
GMN18	**26**	1	GEB10	**37**	**73**	GMN18	**38**	**95**	GEB10	**30**	50
SEB01	**24**	**136**	SLB01	10	**116**	SEB01	**34**	40	SLB01	6	55
SEB02	18	**96**	SLB04	15	**146**	SEB02	**32**	**125**	SLB04	14	**77**
SEB03	16	**70**	SLB05	18	**92**	SEB03	**23**	**112**	SLB05	6	**68**
SEB04	**25**	**85**	SLB06	14	**98**	SEB04	**33**	**91**	SLB06	7	2
SEB05	15	**71**	SLB09	11	54	SEB05	**21**	14	SLB09	6	52
SEB06	17	**90**	SLB13	7	**75**	SEB06	**37**	58	SLB13	**20**	**111**
SEB07	7	**109**	SLB16	7	**74**	SEB07	12	10	SLB16	2	**99**
SEB08	12	**102**	SLB18	**21**	**65**	SEB08	**24**	**112**	SLB18	2	**134**

Table 51: individual phonemic contrasts for German /øː/ vs /œ/ and /iː/ vs /ɪ/.

Regarding /øː/ vs /œ/, monolinguals most typically use both F1 and F2 changes and duration. There is no single early bilingual with no contrast at monolingual level for either combined F1&F2 changes or duration. Likewise, the contrast is very well preserved among SLBs in terms of duration (except for SLB09). In turn, for the /iː/ vs /ɪ/ contrast, speakers GEB04, SEB07, SLB01, SLB06, and SLB09 are below monolingual norm for both formant structure and duration.

yː vs ʏ	ABS_F1+F2	DUR	yː vs ʏ	ABS_F1+F2	DUR	oː vs ɔ	ABS_F1+F2	DUR	oː vs ɔ	ABS_F1+F2	DUR
GMN02	**25**	-5	GEB02	**42**	**76**	GMN02	**21**	**108**	GEB02	15	**95**
GMN03	**30**	**73**	GEB03	**42**	3	GMN03	**24**	**67**	GEB03	16	**68**
GMN07	**26**	8	GEB04	**39**	-13	GMN07	**36**	**66**	GEB04	**41**	**78**
GMN10	**22**	40	GEB05	**30**	-14	GMN10	**52**	43	GEB05	**41**	**62**
GMN11	**44**	20	GEB07	**23**	**61**	GMN11	**43**	**70**	GEB07	**51**	**111**
GMN12	**29**	33	GEB08	17	30	GMN12	**29**	57	GEB08	**38**	**102**
GMN13	**26**	27	GEB09	18	27	GMN13	**20**	**100**	GEB09	**25**	**91**
GMN18	**24**	21	GEB10	**27**	13	GMN18	**30**	26	GEB10	**39**	33
SEB01	**30**	-6	SLB01	**29**	13	SEB01	**24**	39	SLB01	13	44
SEB02	**32**	15	SLB04	**20**	39	SEB02	**35**	**69**	SLB04	14	17
SEB03	**36**	6	SLB05	**23**	15	SEB03	**35**	**84**	SLB05	3	26
SEB04	**22**	19	SLB06	15	57	SEB04	18	49	SLB06	5	33
SEB05	**26**	39	SLB09	**35**	30	SEB05	15	20	SLB09	4	21
SEB06	**20**	**61**	SLB13	18	**157**	SEB06	**21**	27	SLB13	6	33
SEB07	**31**	17	SLB16	**30**	1	SEB07	**22**	12	SLB16	7	-3
SEB08	16	26	SLB18	**21**	**83**	SEB08	19	**90**	SLB18	**33**	18

Table 52: individual phonemic contrasts for German /yː/ vs /ʏ/ and /oː/ vs /ɔ/.

The contrast between /yː/ vs /ʏ/ is not preserved at monolingual level by SLB06, GEB08, GEB09, and SEB08. It must be noted, however, that they are quite close to the reference points. On the contrary, the

/oː/ vs /ɔ/ is very problematic for the late bilinguals, since only SLB18 reaches the values of the monolingual norm for formant structure and none of them for duration. Similarly, SEB04 and SEB05 also deviate from monolinguals in both parameters.

uː vs ʊ	ABS_F1+F2	DUR	uː vs ʊ	ABS_F1+F2	DUR	ɐ vs ə	ABS_F1+F2	DUR	ɐ vs ə	ABS_F1+F2	DUR
GMN02	19	**81**	GEB02	**29**	**144**	GMN02	26	77	GEB02	32	105
GMN03	9	**92**	GEB03	**26**	**109**	GMN03	46	41	GEB03	31	75
GMN07	16	11	GEB04	**31**	35	GMN07	46	59	GEB04	27	32
GMN10	**20**	**61**	GEB05	**30**	**90**	GMN10	36	114	GEB05	38	67
GMN11	18	4	GEB07	**33**	**62**	GMN11	40	49	GEB07	27	42
GMN12	11	**60**	GEB08	13	**72**	GMN12	33	50	GEB08	31	75
GMN13	19	12	GEB09	17	**107**	GMN13	37	43	GEB09	30	80
GMN18	12	46	GEB10	**29**	47	GMN18	42	125	GEB10	39	77
SEB01	**26**	55	SLB01	11	**88**	SEB01	38	44	SLB01	19	24
SEB02	11	**115**	SLB04	6	58	SEB02	31	38	SLB04	24	-6
SEB03	**33**	**82**	SLB05	11	41	SEB03	39	48	SLB05	25	37
SEB04	**23**	**108**	SLB06	8	**65**	SEB04	38	47	SLB06	27	9
SEB05	17	**84**	SLB09	7	**134**	SEB05	27	21	SLB09	18	28
SEB06	**21**	36	SLB13	13	54	SEB06	25	1	SLB13	15	7
SEB07	**28**	**83**	SLB16	5	49	SEB07	24	53	SLB16	28	99
SEB08	15	32	SLB18	10	**68**	SEB08	31	41	SLB18	35	30

Table 53: individual phonemic contrasts for German /uː/vs /ʊ/ and /ɐ/ vs /ə/.

The /uː/ vs /ʊ/ opposition is less robust for German monolinguals than in other tense vs lax contrasts. Only one early bilingual is below monolingual norm (SEB08), whereas four late bilinguals did not reach the monolingual levels of contrast.

Lastly, the pair /ɐ/ vs /ə/ cannot be analysed in terms of tense vs lax, since both vowels belong to the group of unstressed vowels in German. What monolingual data indicate is that duration serves to contrast these two similar sounds, being /ɐ/ longer, but there are also important differences in terms of formant structure of at least 26% for combined F1&F2 (speaker GMN02), but most typically around 38%. As can be seen, some SEBs and SLBs are very close to this bottom-range or even below it.

To conclude, following the procedure at group level, a global note on both duration and combined F1&F2 changes will be given for the whole series of contrasting tense vs lax vowels. As can be seen in table 54, the contrast is maximally contrasted for both groups of early bilinguals, since almost all individuals perform at monolingual for both combined F1&F2 changes and duration. In contrast, no single late bilingual performs monolingual-like in terms of combined F1&F2 changes when all differences for the tense vs lax vowel oppositions are averaged and, what is more, only three of them present duration oppositions comparable to those of monolinguals.

	ABS_F1+F2	DUR		ABS_F1+F2	DUR
GMN02	**21**	**78**	GEB02	**27**	**89**
GMN03	**23**	**71**	GEB03	**24**	**78**
GMN07	**25**	58	GEB04	**26**	46
GMN10	**31**	52	GEB05	**30**	**65**
GMN11	**32**	**68**	GEB07	**28**	**100**
GMN12	**26**	**72**	GEB08	**25**	**113**
GMN13	19	**74**	GEB09	**29**	**95**
GMN18	**24**	41	GEB10	**30**	**56**
SEB01	**25**	54	SLB01	12	53
SEB02	**25**	**84**	SLB04	14	**74**
SEB03	**29**	**74**	SLB05	11	49
SEB04	**24**	**88**	SLB06	10	53
SEB05	17	**68**	SLB09	10	49
SEB06	**24**	**67**	SLB13	11	**68**
SEB07	**25**	**61**	SLB16	11	41
SEB08	**21**	**79**	SLB18	13	**75**

Table 54: mean duration and combined F1&F2 changes for German lax and tense vowels per speaker.

To conclude with the analyses at individual level, differences in the four pairs of homorganic vowels solely distinguished by the feature [± rounded] will be reported. In **bold letters**, appear the speakers whose F3 is zero or positive. As can be seen, the only speakers who constantly fail to implement this feature are SLB06 and SLB09.

Speaker		F1	F2	F3	Speaker		F1	F2	F3
GMN02	y: vs i:	-3	-17	-11	GEB02	y: vs i:	-2	-11	-6
GMN03	y: vs i:	-2	-14	-7	GEB03	y: vs i:	-8	-8	-11
GMN07	y: vs i:	-1	-13	-11	GEB04	y: vs i:	0	14	-4
GMN10	y: vs i:	-5	-13	-6	GEB05	y: vs i:	-7	-11	-9
GMN11	y: vs i:	-4	-6	-5	GEB07	y: vs i:	-8	-12	-5
GMN12	y: vs i:	-2	-11	-10	GEB08	y: vs i:	-5	-16	-11
GMN13	y: vs i:	-5	-10	-7	GEB09	y: vs i:	-4	-27	-16
GMN18	y: vs i:	-2	-15	-7	GEB10	y: vs i:	-4	-20	-9
SEB01	y: vs i:	-3	-9	-9	SLB01	y: vs i:	-6	-10	-8
SEB02	y: vs i:	-5	-9	-5	SLB04	y: vs i:	-7	-11	-9
SEB03	y: vs i:	-3	-1	-6	SLB05	y: vs i:	-2	-17	-5
SEB04	y: vs i:	-1	-15	-9	**SLB06**	y: vs i:	**2**	**-3**	**3**
SEB05	y: vs i:	3	-12	-4	**SLB09**	y: vs i:	**1**	**-9**	**3**
SEB06	y: vs i:	1	-9	-6	SLB13	y: vs i:	-4	-11	-5
SEB07	y: vs i:	-4	-3	-5	SLB16	y: vs i:	-9	-1	-2
SEB08	y: vs i:	1	-13	-10	SLB18	y: vs i:	-6	-16	-12

Table 55: F1, F2, and F3 changes for German /y:/ vs /i:/ per speaker.

Speaker		F1	F2	F3	Speaker		F1	F2	F3
GMN02	ʏ vs ɪ	-3	-13	-8	GEB02	ʏ vs ɪ	-1	-14	-6
GMN03	ʏ vs ɪ	5	-12	-5	GEB03	ʏ vs ɪ	3	-14	-5
GMN07	ʏ vs ɪ	-6	-8	-7	GEB04	ʏ vs ɪ	-3	-12	-5
GMN10	ʏ vs ɪ	-7	-9	-6	GEB05	ʏ vs ɪ	-13	-9	-6
GMN11	ʏ vs ɪ	-9	-17	-3	**GEB07**	ʏ vs ɪ	**-5**	**5**	**2**
GMN12	ʏ vs ɪ	-8	-11	-5	GEB08	ʏ vs ɪ	-6	-6	-3
GMN13	ʏ vs ɪ	-6	-5	-8	GEB09	ʏ vs ɪ	-14	-16	-10
GMN18	ʏ vs ɪ	-4	-6	-2	GEB10	ʏ vs ɪ	-4	-18	-6
SEB01	ʏ vs ɪ	-4	-7	-4	SLB01	ʏ vs ɪ	-7	-29	-7
SEB02	ʏ vs ɪ	-6	-10	-2	SLB04	ʏ vs ɪ	-6	-15	-2
SEB03	ʏ vs ɪ	-8	-14	-6	SLB05	ʏ vs ɪ	7	-32	-7
SEB04	ʏ vs ɪ	-5	-9	-3	**SLB06**	ʏ vs ɪ	**-1**	**-13**	**0**
SEB05	ʏ vs ɪ	-1	-18	-5	SLB09	ʏ vs ɪ	-11	-30	-5
SEB06	ʏ vs ɪ	-12	-5	-5	SLB13	ʏ vs ɪ	-2	-8	-4
SEB07	ʏ vs ɪ	-1	-15	-6	SLB16	ʏ vs ɪ	-2	-19	-3
SEB08	ʏ vs ɪ	-9	-14	-4	SLB18	ʏ vs ɪ	3	-26	-12

Table 56: F1, F2, and F3 changes for German /ʏ/ vs /ɪ/ per speaker.

Speaker		F1	F2	F3	Speaker		F1	F2	F3
GMN02	ø: vs e:	-3	-28	-10	GEB02	ø: vs e:	-10	-20	-5
GMN03	ø: vs e:	-2	-23	-6	GEB03	ø: vs e:	-9	-28	-8
GMN07	ø: vs e:	-6	-20	-10	GEB04	ø: vs e:	3	-16	-6
GMN10	ø: vs e:	1	-26	-9	GEB05	ø: vs e:	-10	-19	-3
GMN11	ø: vs e:	-2	-33	-6	GEB07	ø: vs e:	2	-15	-5
GMN12	ø: vs e:	-6	-23	-5	GEB08	ø: vs e:	-1	-27	-12
GMN13	ø: vs e:	1	-18	-4	GEB09	ø: vs e:	-10	-33	-14
GMN18	ø: vs e:	0	-26	-9	GEB10	ø: vs e:	-5	-27	-8
SEB01	ø: vs e:	-2	-20	-7	SLB01	ø: vs e:	-11	-15	-9
SEB02	ø: vs e:	-3	-25	-8	SLB04	ø: vs e:	-8	-10	-6
SEB03	ø: vs e:	0	-28	-11	SLB05	ø: vs e:	-9	-25	-6
SEB04	ø: vs e:	1	-20	-3	**SLB06**	ø: vs e:	**-2**	**-8**	**1**
SEB05	ø: vs e:	0	-11	-6	**SLB09**	ø: vs e:	**-5**	**-13**	**0**
SEB06	ø: vs e:	-9	-18	-6	SLB13	ø: vs e:	-12	-16	-9
SEB07	ø: vs e:	8	-23	-10	SLB16	ø: vs e:	-26	-2	-1
SEB08	ø: vs e:	3	-21	-11	SLB18	ø: vs e:	-17	-25	-9

Table 57: F1, F2, and F3 changes for German /ø:/ vs /e:/ per speaker.

Speaker		F1	F2	F3	Speaker		F1	F2	F3
GMN02	œ vs ɛ	1	-4	-2	**GEB02**	œ vs ɛ	**4**	**3**	**3**
GMN03	œ vs ɛ	**-16**	**1**	**0**	GEB03	œ vs ɛ	-18	-1	-3
GMN07	œ vs ɛ	-8	-14	-3	GEB04	œ vs ɛ	9	-10	-4
GMN10	œ vs ɛ	**0**	**23**	**3**	**GEB05**	œ vs ɛ	**12**	**3**	**1**
GMN11	œ vs ɛ	-8	-13	-6	**GEB07**	œ vs ɛ	**-5**	**-8**	**0**
GMN12	œ vs ɛ	-7	-10	-7	**GEB08**	œ vs ɛ	**-10**	**10**	**1**
GMN13	œ vs ɛ	-2	-10	-5	**GEB09**	œ vs ɛ	**3**	**4**	**3**
GMN18	œ vs ɛ	0	-10	-3	GEB10	œ vs ɛ	2	-3	-1
SEB01	œ vs ɛ	**-4**	**-3**	**0**	SLB01	œ vs ɛ	-9	-13	-8
SEB02	œ vs ɛ	**-9**	**-7**	**0**	SLB04	œ vs ɛ	-9	-15	-7
SEB03	œ vs ɛ	-12	-18	-3	SLB05	œ vs ɛ	-4	-18	-3
SEB04	œ vs ɛ	**4**	**7**	**3**	**SLB06**	œ vs ɛ	**-3**	**-2**	**1**
SEB05	œ vs ɛ	**1**	**-4**	**3**	**SLB09**	œ vs ɛ	**-1**	**-13**	**1**
SEB06	œ vs ɛ	**-1**	**14**	**5**	SLB13	œ vs ɛ	-8	-10	-6
SEB07	œ vs ɛ	-3	-14	-6	SLB16	œ vs ɛ	-8	-3	-1
SEB08	œ vs ɛ	**-2**	**1**	**3**	SLB18	œ vs ɛ	-3	-17	-11

Table 58: F1, F2, and F3 changes for German /œ/ vs /ɛ/ per speaker.

Speaker	r vs unr	F1	F2	F3	Speaker	r vs unr	F1	F2	F3
GMN02	r vs unr	-2	-15	-8	GEB02	r vs unr	-2	-11	-3
GMN03	r vs unr	-4	-12	-4	GEB03	r vs unr	-8	-13	-7
GMN07	r vs unr	-5	-14	-8	GEB04	r vs unr	2	-6	-5
GMN10	r vs unr	-3	-6	-5	GEB05	r vs unr	-4	-9	-4
GMN11	r vs unr	-6	-17	-5	GEB07	r vs unr	-4	-7	-2
GMN12	r vs unr	-6	-14	-7	GEB08	r vs unr	-6	-10	-6
GMN13	r vs unr	-3	-11	-6	GEB09	r vs unr	-6	-18	-9
GMN18	r vs unr	-1	-14	-5	GEB10	r vs unr	-3	-17	-6
SEB01	r vs unr	-3	-10	-5	SLB01	r vs unr	-8	-17	-8
SEB02	r vs unr	-6	-13	-4	SLB04	r vs unr	-8	-13	-6
SEB03	r vs unr	-6	-15	-7	SLB05	r vs unr	-2	-23	-5
SEB04	r vs unr	0	-9	-3	**SLB06**	**r vs unr**	**-1**	**-7**	**1**
SEB05	r vs unr	1	-11	-3	**SLB09**	**r vs unr**	**-4**	**-16**	**0**
SEB06	r vs unr	-5	-5	-3	SLB13	r vs unr	-7	-11	-6
SEB07	r vs unr	0	-14	-7	SLB16	r vs unr	-11	-6	-2
SEB08	r vs unr	-2	-12	-5	SLB18	r vs unr	-6	-21	-11

Table 59: F1, F2, and F3 changes for German rounded vs unrounded vowels per speaker.

3.4.2 Stops

3.4.2.1 Methodology

In this section, data from two different tasks are reported. Data for absolute initial position were obtained by means of the VOT task already described in 3.1.2, whereas those in intervocalic position were elicited during the semi-spontaneous speech task described in 3.1.3. All tokens from the VOT task as well as all sentences used are available in the appendix.

For absolute initial position, i.e. for the data from the VOT task, all consonants appear in stressed position and followed by each of the five Spanish vowels and each of the seven German long vowels. Altogether, 30 and 42 measurements per speaker were taken for Spanish and German, respectively.

In absolute initial position, the proportion of lenis items produced with the feature [± voicing] in each language was calculated. Given that in initial position canonical Spanish and German lenis pronunciations differ in [± voicing], deviant realisations can be easily identified: /b d ɡ/ Spanish tokens with [-voicing] and German ones with [+voicing] can be classified as non-canonical. The proportion of these non-canonical realisations will be first reported. The same procedure cannot be carried out for fortis tokens since there is not objective cut-point from which stops can be classified as aspirated. Secondly, those tokens that were canonical in terms of [± vibration] were acoustically analysed in order to investigate whether they were phonetically different. Specifically, VOT and post-stop vowel duration were measured with a script (Buchholz, 2016).

For intervocalic positions, twelve tokens per language and speaker (two per phoneme) were measured in unstressed position. Firstly, the phonological stops were categorically classified as stops or approximants depending on their phonetic form after visual inspection in the spectrogram; secondly, VOT was measured for fortis stops; thirdly, total segment duration was calculated with the above-mentioned script after manual segmentation; and finally, the voiced part was also manually segmented and its duration extracted with the same script.

Unlike when reporting other parts of the acoustic analyses, it has been decided that the results for the stops will not be split into Spanish and German data, but into absolute initial and intervocalic position. The rationale behind this decision is that, albeit with noticeable phonetic differences, this sound class is the only one in which both share the same set of phonemes; therefore, a combined presentation is more pertinent due to the constant interactions between the two languages of the speakers.

3.4.2.2 Results

3.4.2.2.1 Stressed absolute initial position

Table 60 corroborates that, as reviewed in 2.1.2.1 and 2.1.2.2, whereas non-canonical realisations are extremely rare among Spanish monolinguals, voiced /b d ɡ/ realisations in German, despite clearly not representing the typical pronunciation, are a legitimate option some monolingual speakers make use of (for instance, speaker GMN03, who produces one of each two /b d ɡ/ tokens with voicing). As noted in the review, what is crucial in German is the presence or absence of the feature [± aspiration]. The presence of voicing can serve to maximally contrast with aspirated sounds, and might have some sociophonetic value attached to it, but is redundant in phonological terms, since the absence of aspiration is enough to mark the contrast. Therefore, it is not surprising that all bilingual groups present higher percentages of non-canonical realisations in German than in Spanish.

SPANISH								GERMAN							
SMN		SLB		SEB		GEB		GMN		GEB		SEB		SLB	
/b/		/b/	4	/b/	3	/b/	4	/b/	5	/b/	14	/b/	18	/b/	29
/d/		/d/	4	/d/	2	/d/	10	/d/	3	/d/	10	/d/	17	/d/	22
/g/	1	/g/	18	/g/	5	/g/	11	/g/	3	/g/	10	/g/	12	/g/	26
Total	1	Total	26	Total	10	Total	25	Total	11	Total	34	Total	47	Total	77
%	0.83	%	20.83	%	8.33	%	21.55	%	9.16	%	28.33	%	39.17	%	64.17

Table 60: non-canonical /b d g/ realisations for Spanish and German across groups in absolute initial position.

As for the SLBs, it is worth noting that 20% of their Spanish /b d g/ tokens are produced voiceless, what is a clear sign of phonetic transfer, but at the same time most of their German /b d g/ tokens are voiced, i.e. not target-like. In other words, this group shows bi-directional transfer, although the flux from Spanish into German is much more intense. Likewise, the SEB group also presents bi-directional transfer, but, anew, the Spanish→German flux is more intense than the German→Spanish one. Lastly, the GEB group patterns together with the other bilinguals in presenting more deviating /b d g/ tokens in German than in Spanish, which, at first glance, may look striking for a group of speakers brought up in Germany. It is, nonetheless, congruent with the fact that deviations in voicing affect a primary feature in Spanish whereas only a secondary one in German.

SMN10	0%	GEB10	0%	SEB01	0%	SLB01	7%	GMN10	0%	GEB10	13%	SEB01	67%	SLB01	100%
SMN11	0%	GEB02	20%	SEB02	0%	SLB13	7%	GMN11	7%	GEB02	27%	SEB02	0%	SLB13	80%
SMN14	0%	GEB03	13%	SEB03	0%	SLB16	27%	GMN12	7%	GEB03	13%	SEB03	87%	SLB16	93%
SMN15	0%	GEB04	7%	SEB04	27%	SLB18	53%	GMN13	13%	GEB04	93%	SEB04	7%	SLB18	67%
SMN16	0%	GEB05	27%	SEB05	7%	SLB04	27%	GMN18	0%	GEB05	20%	SEB05	53%	SLB04	20%
SMN03	0%	GEB07	20%	SEB06	0%	SLB05	27%	GMN02	0%	GEB07	0%	SEB06	20%	SLB05	67%
SMN07	0%	GEB08	86%	SEB07	7%	SLB06	7%	GMN03	47%	GEB08	0%	SEB07	0%	SLB06	60%
SMN08	7%	GEB09	0%	SEB08	27%	SLB09	13%	GMN07	0%	GEB09	60%	SEB08	80%	SLB09	27%

Table 61**:** non-canonical /b d g/ realisations for Spanish and German per individual in absolute initial position.

Group means, however, mask the enormous intra-group variation (table 61). For instance, speaker SLB18 is responsible for almost a third of all deviant Spanish pronunciations in her group; she produces half of her /b d g/ tokens without voicing, which is an unmistakable sign of language attrition. Additionally, all other SLB speakers show at least one case of L2. Remarkable is the case of speaker SLB04, who is the only late bilingual whose German→Spanish flux is more intense (albeit only slightly) than the Spanish→German one. In addition, she (along with speaker SLB09) is one of the two speakers that have a deviation-ratio in German below 50%. Interestingly, the performance of these two speakers is also the best when both languages are considered. By contrast, speakers SLB01, SLB13, and SLB16 never or seldom produce voiceless German tokens for /b d g/.

In turn, German transfer can be detected in only half of the SEB speakers, and when it does take place, it is generally mild (27% at highest). For German, however, individuals in this group are less homogeneous. On the one hand, SEB03 and SEB08, and to a lesser extent SEB01 and SEB05, show visible signs of Spanish transfer into German; on the other, SEB02 and SEB07 produced all their German /b d ɡ/ tokens target-like, and SEB04 and SEB06 are quite close to it. Especially remarkable is the case of SEB02, whose efficiency in reaching target-like pronunciations in both languages is total and, to a lesser extent, SEB07, SEB06, and SEB04, who also produce very high percentages of canonical pronunciations in both languages.

Lastly, as expected, most extreme cases of German transfer into Spanish occur in the GEB group, namely, speaker GEB08 produces most of her /b d ɡ/ tokens without voicing. On the contrary, all Spanish tokens are target-like for GEB10 and GEB09. Likewise, the individual data for German also confirm that ranges within bilingual samples can be extreme. Particularly interesting is the case of speaker GEB04, who produced nearly all her /b d ɡ/ tokens with voicing. This case is of great interest, since virtually all her Spanish tokens were also voiced, which seemingly indicates that she has adopted a single pronunciation for absolute initial position in both languages, but what is most striking is that she has chosen to favour the Spanish pronunciation, in spite of being brought up in Germany. To some extent, this is also the case of speaker GEB09, whose Spanish /b d ɡ/ tokens were always voiced and her German ones are often voiced. On the contrary, most of the Spanish /b d ɡ/ pronunciations of speaker GEB08 are voiceless, whereas none is voiced in German. She represents, therefore, the opposite case to speaker GEB04 inasmuch she has mostly adopted a single phonetic form for both Spanish and German /b d ɡ/, which makes her indistinguishable from German monolingual peers, but causes her to fail to correctly implement the feature [± voicing] in Spanish. Quite the opposite, speaker GEB10, GEB7, and GEB03 seemingly possess a very high degree of phonetic awareness, since most of their /b d ɡ/ tokens are canonical in both languages.

For the phonetic analysis, both VOT and post-stop vowel duration will be reported. The former needs no justification, since they directly affect stops productions, on the other hand, measurements on post-stop vowels were deemed to be pertinent because, as reviewed in 2.1.2, the feature [tenseness], whose acoustic correlate is the stop/vowel-ratio, is also relevant for the study of Spanish and German stops.

GROUP		VOT	GROUP		VOT	GROUP		VOT	GROUP		VOT
SMN	b	-76	SEB	b	-79	GMN	b	13	SEB	b	10
SMN	d	-73	SEB	d	-68	GMN	d	15	SEB	d	12
SMN	g	-58	SEB	g	-68	GMN	g	25	SEB	g	22
SMN	p	12	SEB	p	13	GMN	p	54	SEB	p	49
SMN	t	14	SEB	t	15	GMN	t	64	SEB	t	73
SMN	k	26	SEB	k	34	GMN	k	78	SEB	k	77
SLB	b	-64	GEB	b	-85	GEB	b	11	SLB	b	17
SLB	d	-65	GEB	d	-82	GEB	d	13	SLB	d	15
SLB	g	-56	GEB	g	-63	GEB	g	24	SLB	g	22
SLB	p	20	GEB	p	12	GEB	p	56	SLB	p	25
SLB	t	22	GEB	t	15	GEB	t	67	SLB	t	38
SLB	k	39	GEB	k	32	GEB	k	77	SLB	k	54

Table 62: VOT for Spanish and German stops in absolute initial position.

The Mann-Whitney tests (two-tailed) revealed that there was no significant difference between SMN and GEB speakers, however, SEBs differed from Spanish monolinguals in VOT for /g/ (p = .096), which nonetheless only reflects that pre-voicing lasted slightly longer for SEBs. In turn, the late bilinguals differed significantly for all fortis stops: for /p/ (p = .0001), /t/ (p = .0001), and /k/ (p = 0.01). Albeit in the direction typical of language transfer, the lengthening in VOT for the SLBs is relatively modest and not enough to produce clearly aspirated consonants. In turn, there was no statistical difference between GEBs and GMNs, whereas GMNs and SEBs differed only in /b/ and /g/, but the absolute values show that this difference is completely negligible from an auditory point of view. Lastly, the late bilinguals present significant differences for the three fortis stops (p = .0001 for each of them). A comparison between the SLBs' two languages makes patent that they are aware that they have to aspirate their /p t k/ tokens in German. Nonetheless, they fail to phonetically resemble German monolinguals.

Table 63 shows the relative changes in vowel duration after homorganic stops in both languages (after excluding non-canonical productions in terms of [± voicing]).

SMN	bilabial	-16	SEB	bilabial	-24	GMN	bilabial	-23	SEB	bilabial	-32
	alveolar	-13		alveolar	-4		alveolar	-9		alveolar	-6
	velar	-16		velar	-15		velar	3		velar	20
SLB	bilabial	-30	GEB	bilabial	-18	GEB	bilabial	-29	SLB	bilabial	-47
	alveolar	-13		alveolar	-14		alveolar	-16		alveolar	-14
	velar	-15		velar	-19		velar	2		velar	19

Table 63: relative changes (%) of vowel duration after fortis stops in relation to their lenis counterpart.

As can be seen, vowels are shorter after all fortis stops in both languages except after the velar fortis in German, which is roughly equal (for GMNs and GEBs) or even longer (SEBs and SLBs). Indeed, changes in vowel length are quite similar for both Spanish and German monolinguals despite the differences in voicing and aspiration.

In what follows, VOT and vowel length after fortis and lenis stops will also be reported at individual level. For Spanish VOT, SLB18 stands out again, as she produces both more voiced and aspirated tokens. In the rest of groups, nothing is remarkable at individual level.

Group		VOT	Group		VOT	Group		VOT	Group		VOT
SMN03	Fortis	21	SLB01	Fortis	22	SEB01	Fortis	17	GEB02	Fortis	31
SMN03	Lenis	-52	SLB01	Lenis	-86	SEB01	Lenis	-91	GEB02	Lenis	-121
SMN07	Fortis	14	SLB04	Fortis	26	SEB02	Fortis	23	GEB03	Fortis	15
SMN07	Lenis	-60	SLB04	Lenis	-55	SEB02	Lenis	-77	GEB03	Lenis	-55
SMN08	Fortis	13	SLB05	Fortis	29	SEB03	Fortis	18	GEB04	Fortis	15
SMN08	Lenis	-75	SLB05	Lenis	-73	SEB03	Lenis	-82	GEB04	Lenis	-93
SMN10	Fortis	16	SLB06	Fortis	23	SEB04	Fortis	23	GEB05	Fortis	13
SMN10	Lenis	-62	SLB06	Lenis	-50	SEB04	Lenis	-47	GEB05	Lenis	-52
SMN11	Fortis	19	SLB09	Fortis	27	SEB05	Fortis	20	GEB07	Fortis	19
SMN11	Lenis	-64	SLB09	Lenis	-34	SEB05	Lenis	-59	GEB07	Lenis	-44
SMN14	Fortis	20	SLB13	Fortis	27	SEB06	Fortis	21	GEB08	Fortis	24
SMN14	Lenis	-66	SLB13	Lenis	-71	SEB06	Lenis	-56	GEB08	Lenis	-69
SMN15	Fortis	21	SLB16	Fortis	23	SEB07	Fortis	18	GEB09	Fortis	17
SMN15	Lenis	-79	SLB16	Lenis	-59	SEB07	Lenis	-68	GEB09	Lenis	-67
SMN16	Fortis	16	SLB18	Fortis	42	SEB08	Fortis	24	GEB10	Fortis	22
SMN16	Lenis	-95	SLB18	Lenis	-74	SEB08	Lenis	-83	GEB10	Lenis	-100

Table 64: VOT for Spanish fortis and lenis stops per individual.

Group		VOT	Group		VOT	Group		VOT	Group		VOT
GMN02	Fortis	78	GEB02	Fortis	82	SEB01	Fortis	79	SLB01	Fortis	20
GMN02	Lenis	20	GEB02	Lenis	18	SEB01	Lenis	14	SLB01	Lenis	ND
GMN03	Fortis	61	GEB03	Fortis	56	SEB02	Fortis	66	SLB04	Fortis	40
GMN03	Lenis	16	GEB03	Lenis	13	SEB02	Lenis	17	SLB04	Lenis	14
GMN07	Fortis	70	GEB04	Fortis	62	SEB03	Fortis	59	SLB05	Fortis	34
GMN07	Lenis	19	GEB04	Lenis	16	SEB03	Lenis	17	SLB05	Lenis	15
GMN10	Fortis	62	GEB05	Fortis	56	SEB04	Fortis	62	SLB06	Fortis	45
GMN10	Lenis	18	GEB05	Lenis	12	SEB04	Lenis	17	SLB06	Lenis	19
GMN11	Fortis	50	GEB07	Fortis	56	SEB05	Fortis	54	SLB09	Fortis	42
GMN11	Lenis	16	GEB07	Lenis	20	SEB05	Lenis	19	SLB09	Lenis	23
GMN12	Fortis	66	GEB08	Fortis	76	SEB06	Fortis	60	SLB13	Fortis	42
GMN12	Lenis	14	GEB08	Lenis	19	SEB06	Lenis	15	SLB13	Lenis	26
GMN13	Fortis	65	GEB09	Fortis	72	SEB07	Fortis	ND	SLB16	Fortis	46
GMN13	Lenis	20	GEB09	Lenis	15	SEB07	Lenis	ND	SLB16	Lenis	18
GMN18	Fortis	67	GEB10	Fortis	74	SEB08	Fortis	63	SLB18	Fortis	42
GMN18	Lenis	17	GEB10	Lenis	14	SEB08	Lenis	7	SLB18	Lenis	13

Table 65: VOT for Spanish fortis and lenis stops per individual.

Interestingly, speaker SLB18 has the same mean for fortis stops in both languages, which is too high for Spanish and too low German standards, i.e. this particular aspect has merged. A note on speaker SLB01 must also be made, she has no mean for lenis stops because, as noted in this section, only canonical stops in terms of voicing were considered for the elaboration of this table and all her /b d g/

tokens were voiced. Likewise, her fortis stops are clearly unaspirated. On the contrary, the lack of data for speaker SEB07 is due to a technical problem with the recorder. Lastly, tenseness affects the duration of the following vowel (table 66); in this regard, nothing remarkable occurred in the Spanish data, but speakers SLB13 and SLB16 differed from their peers in presenting abnormal values for German, for which vowel pronunciations may be responsible rather than actual differences in tenseness.

SMN03	-23	SLB01	-13	SEB01	-18	GEB02	-17	GMN02	-7	GEB02	-12	SEB01	-5	SLB01	ND
SMN07	-15	SLB04	-27	SEB02	-15	GEB03	-13	GMN03	-10	GEB03	-10	SEB02	-23	SLB04	-5
SMN08	-13	SLB05	-15	SEB03	-25	GEB04	-18	GMN07	-4	GEB04	-50	SEB03	4	SLB05	-21
SMN10	-6	SLB06	-22	SEB04	-20	GEB05	-28	GMN10	-9	GEB05	-22	SEB04	-6	SLB06	-14
SMN11	-12	SLB09	-20	SEB05	-20	GEB07	-16	GMN11	-14	GEB07	-15	SEB05	0	SLB09	-7
SMN14	-16	SLB13	-25	SEB06	-13	GEB08	-21	GMN12	-13	GEB08	-15	SEB07	ND	SLB13	3
SMN15	-21	SLB16	-19	SEB07	-12	GEB09	-8	GMN13	-12	GEB09	-10	SEB06	4	SLB16	21
SMN16	-15	SLB18	-28	SEB08	-9	GEB10	-21	GMN18	-12	GEB10	-24	SEB08	-32	SLB18	-10

Table 66: relative changes (%) of vowel duration after fortis stops in relation to their lenis counterpart.

3.4.2.2.2 Unstressed intervocalic position

The main phonological difference between Spanish and German is that in Spanish it is compulsory to weaken phonological /b d g/ stops into approximants. Deviations in the application of this phonological rule are minimal for all groups, including the GEB group, which, in principle, would be the most prone to produce stops because of their dominance in German. Likewise, approximant realisations for /p t k/ tokens, which have also been reported in the literature (see 2.1.2.2) are also extremely rare in this corpus.

Spanish	bdg		ptk		German	bdg		ptk	
Group	Stop	Approx.	Stop	Approx.	Group	Stop	Approx.	Stop	Approx.
SMN	2	98	100		**GMN**	71	29	100	
SLB	2	98	98	2	**GEB**	86	14	100	
SEB	2	98	100		**SEB**	67	33	100	
GEB	5	95	100		**SLB**	68	32	100	

Table 67: stops and approximant per fortis and lenis stops in unstressed intervocalic position in Spanish and German given in percentages.

On the contrary, the high proportion of approximant tokens in German in the monolingual group (29%) is relatively surprising. Most general manuals do not even describe the approximant as a possible realisation, but Kohler ([2]1995: 209) notes that approximants are especially common in weak forms like the auxiliary verb *haben* 'to have' and in general in unstressed position (like all intervocalic stops here measured). Given that such approximant realisations are possible in German as noted by Kohler one could expect that, as a result of their Spanish competence, all bilinguals would make use of this possibility even to a greater extent. The results indicate, however, quite the contrary: the stop/approximant ratio is practically identical for GMNs, SEBs, and SLBs, and what is more, approximant productions among GEBs represent only half of what they represent for GMNs. Kohler

(^{2}1995: 209) also adds that /d/ is seldom articulated as an approximant, which is indeed the case for both GMNs and GEBs, but SLBs, quite the contrary, tend to produce this sound as approximant (table 68). Kohler (^{2}1995: 209) provides an articulatory explanation whereby alveolar approximants are less prone to occur in German than bilabial and velar ones since the apex moves faster than lips and the root of the tongue. In Spanish, however, the approximant form for /d/ also changes of place of articulation and becomes interdental [ð̞], which is most likely the actual realisation of SLB and SEB speakers for those German tokens.

SPA		Stop	Approx.			Stop	Approx.	GER		Stop	Approx.			Stop	Approx.
SMN	**b**	6	94	**GEB**	**b**		100	**GMN**	**b**	60	40	**GEB**	**b**	88	12
	d		100		**d**	15	85		**d**	88	12		**d**	88	12
	g		100		**g**		100		**g**	63	37		**g**	82	18
SEB	**b**		100	**SLB**	**b**		100	**SEB**	**b**	81	19	**SLB**	**b**	6	94
	d		100		**d**	8	92		**d**	69	31		**d**	33	67
	g	6	94		**g**	12	88		**g**	50	50		**g**	56	44

Table 68: stops and approximants per phonological stop in unstressed intervocalic position in Spanish and German.

This calculus of the proportion of approximant and stop tokens was repeated at individual level and yielded very homogeneous results for Spanish /b d g/ tokens, which are overwhelmingly pronounced as approximants. The only speakers who produced at least one token as a stop were SMN16, SLB01, SLB05, SEB06, GEB05, and GEB10. However, only the case of speaker SLB01 is remarkable; 40% of her Spanish /b d g/ tokens are not lenited into approximants. The German results are, on the contrary, more diverse and therefore presented in table 69. Remarkably, speaker GMN03 produces approximant tokens more often than not in this position, indeed, presents the highest ratio across groups. Such realisations are also very frequent among GMN10, GEB09, SEB02, and SEB06. In turn, no late bilingual overwhelmingly produces approximants for German /b d g/, but all of them do it with certain regularity except for SLB04.

GMN02	Approx	17	GEB02	Approx	17	SEB01	Approx	33	SLB01	Approx	33
GMN03	Approx	67	GEB03	Approx	17	SEB02	Approx	50	SLB04	Approx	17
GMN07	Approx	17	GEB04	Approx	0	SEB03	Approx	0	SLB05	Approx	40
GMN10	Approx	50	GEB05	Approx	0	SEB04	Approx	0	SLB06	Approx	33
GMN11	Approx	33	GEB07	Approx	17	SEB05	Approx	33	SLB09	Approx	33
GMN12	Approx	17	GEB08	Approx	0	SEB06	Approx	67	SLB13	Approx	33
GMN13	Approx	0	GEB09	Approx	57	SEB07	Approx	50	SLB16	Approx	33
GMN18	Approx	33	GEB10	Approx	0	SEB08	Approx	33	SLB18	Approx	33

Table 69: proportion of approximant tokens per phonological lenis stops in German.

In what follows, the first phonetic parameter measured for this position will be presented, namely VOT for fortis stops. For Spanish lenis stops it could not be measured since they are no actual stops, but approximants, and as this sound class was also very present among German realisations, it was decided to focus just on fortis stops. Table 70, on the one hand, and tables 71 and 72, on the other, present these data at group and at individual level, respectively.

	SMN	SLB	SEB	GEB		GMN	GEB	SEB	SLB
p	10	13	10	13	p	23	22	18	17
t	14	16	14	18	t	49	46	27	31
k	19	21	19	22	k	30	28	29	31

Table 70: VOT for Spanish and German intervocalic stops per groups.

The Mann-Whitney tests yielded no significant differences between SMNs and any of the three bilingual groups for VOT in any of the three phonemes. By contrast, both SEBs and SLBs differed from GMNs for /t/ VOT (p = <.0001 and p = .004, respectively). The VOT of the German monolinguals are not particularly high, albeit considerably more than those produced by SMNs. It is important to note that they cannot be directly compared with those from absolute initial position for two reasons: in this position, all syllables were unstressed and, probably most importantly, they were produced in the middle of a sentence instead of in isolated words, as in absolute initial position. Lastly, a further aspect worth noting at group level is that all bilingual groups present higher VOT in German than in Spanish.

SMN03	15	SLB01	22	SEB01	16	GEB02	17
SMN07	8	SLB04	19	SEB02	16	GEB03	26
SMN08	13	SLB05	14	SEB03	18	GEB04	17
SMN10	8	SLB06	15	SEB04	11	GEB05	18
SMN11	17	SLB09	15	SEB05	13	GEB07	11
SMN14	14	SLB13	20	SEB06	13	GEB08	14
SMN15	21	SLB16	11	SEB07	13	GEB09	23
SMN16	16	SLB18	16	SEB08	18	GEB10	14

Table 71: VOT for Spanish fortis stops in intervocalic position per individual.

GMN02	37	GEB02	35	SEB01	21	SLB01	23
GMN03	47	GEB03	38	SEB02	27	SLB04	41
GMN07	39	GEB04	34	SEB03	33	SLB05	15
GMN10	23	GEB05	32	SEB04	17	SLB06	16
GMN11	23	GEB07	27	SEB05	27	SLB09	33
GMN12	37	GEB08	31	SEB06	16	SLB13	24
GMN13	40	GEB09	35	SEB07	27	SLB16	33
GMN18	29	GEB10	23	SEB08	28	SLB18	27

Table 72: VOT for German fortis stops in intervocalic position per individual.

At individual level, there is no bilingual speaker with particularly anomalous VOT, except for GEB09 for /p/ and GEB03 for /k/ in Spanish. However, several SEB and SLB speakers produce relatively low VOT values for German, e.g. SLB01, SLB05, SLB06, SEB01, SEB04, and SEB06. Lastly, it is of interest to identify those speakers with markedly different VOT values for each language. For that purpose, mean VOT across /p t k/ was calculated for both languages as well as the difference between the German and Spanish means (table 73). As can be seen, speakers GEB10, SLB01, SLB05, SLB06, SLB13, SEB01, SEB04, and SEB06 do not implement different VOT in their two languages or present only minimal differences.

GEB02	18	SLB01	0	SEB01	5
GEB03	11	SLB04	22	SEB02	11
GEB04	17	SLB05	1	SEB03	15
GEB05	13	SLB06	1	SEB04	6
GEB07	17	SLB09	18	SEB05	14
GEB08	17	SLB13	4	SEB06	3
GEB09	12	SLB16	22	SEB07	14
GEB10	9	SLB18	11	SEB08	10

Table 73: difference (ms) between German and Spanish averaged /p t k/ VOT per speaker.

The other parameter measured was the extent of the voiced portion (henceforth voiced%) per phonetic stop, i.e. excluding approximant realisations, for both voiced and voiceless and stops. In Spanish, there is a clear tendency for voicing to occur less naturally when the stop has a more retracted position. In addition, the means indicate that many of these allegedly voiceless tokens are indeed more voiced than not, which was to be expected given their dialectal background (see 2.1.2.2 for a review of voicing in voiceless stops). The contrast with their phonologically voiced counterparts is, nonetheless, robust, since lenis stops are lenited into approximants, which serves to create a robust contrast in terms of duration (table 75).

GERMAN	b	d	g	p	t	k	SPANISH	p	t	k
GMN	93	99	85	47	33	23	**SMN**	55	40	39
GEB	86	89	86	36	30	22	**SLB**	45	32	28
SEB	83	92	82	21	32	17	**SEB**	47	41	29
SLB	79	78	47	37	33	21	**GEB**	35	23	19

Table 74: percentage of voiced portion during occlusion.

Regarding German, group differences are minimal between GMN, GEB, and SLB speakers for fortis stops except for /p/, slightly more voiced for the German monolinguals. In turn, /p/ presents a proportion of particularly low passive voicing among SEBs. More drastic are, however, the differences in voiced% for lenis stops; particularly for the late bilinguals, who ostensibly produce /b d g/ tokens with less voicing than German monolinguals. One possible explanation for this is that duration is most likely more perceptually relevant in this position than voicing in their L1 Spanish. This view has been defended in Martínez Celdrán & Fernández Planas (^{2}2013: 63-85) and seems particularly true for dialects in which /p t k/ present large voiced portions (e.g. that of most SLBs and that of the SMNs). This smaller voicing sensitivity by part of the SLBs would have resulted in stops with less sustained voicing. However, it follows from this explanation that GMNs do have a special sensitivity for voicing in this position, which is supported by the data in table 74, but go against Beckman et al. (2013), whose findings suggest that German is not a truly voicing language for intervocalic stops. What is clear, however, is that duration is contrasts for stops are very marked in both languages, but considerably more in Spanish (table 75).

SPANISH		Fortis vs Lenis	GERMAN		Fortis vs Lenis
SMN	bilabial	148%	GMN	bilabial	98%
SMN	alveolar	281%	GMN	alveolar	139%
SMN	velar	55%	GMN	velar	109%
SLB	bilabial	181%	GEB	bilabial	74%
SLB	alveolar	241%	GEB	alveolar	152%
SLB	velar	126%	GEB	velar	84%
SEB	bilabial	193%	SEB	bilabial	54%
SEB	alveolar	191%	SEB	alveolar	186%
SEB	velar	119%	SEB	velar	96%
GEB	bilabial	197%	SLB	bilabial	87%
GEB	alveolar	303%	SLB	alveolar	153%
GEB	velar	134%	SLB	velar	123%

Table 75: relative duration increases for intervocalic fortis stops.

Anew, individual data shed much light into the discussion. In Spanish, voicing cannot be the main distinctive feature for speakers of central Spanish, since some of their tokens are fully voiced; an example thereof is given in figure 9. Nonetheless, it is not infrequent that the same speaker alternates tokens with full or almost full voicing with others with little passive voicing.

Voiced%	ptk		ptk		ptk		ptk
SMN03	68	SLB01	36	SEB01	30	GEB02	16
SMN07	60	SLB04	42	SEB02	32	GEB03	30
SMN08	36	SLB05	27	SEB03	55	GEB04	24
SMN10	40	SLB06	33	SEB04	25	GEB05	41
SMN11	30	SLB09	45	SEB05	39	GEB07	23
SMN14	46	SLB13	49	SEB06	50	GEB08	10
SMN15	38	SLB16	28	SEB07	52	GEB09	42
SMN16	38	SLB18	33	SEB08	26	GEB10	20

Table 76: percentage of voiced portion per individual in Spanish intervocalic stops.

Generally, central Spaniards voice /p t k/ more often than other speakers (table 74), some speakers of American varieties, e.g. SEB03, SEB06 and SEB07, can also present high voiced% values. By contrast, only one German monolingual presented a voiced% value over 50% (GMN03). Furthermore, at least six speakers seem might be aware that voicing is more important for this contrast in German, as their voiced% values decrease in German in relation to Spanish.

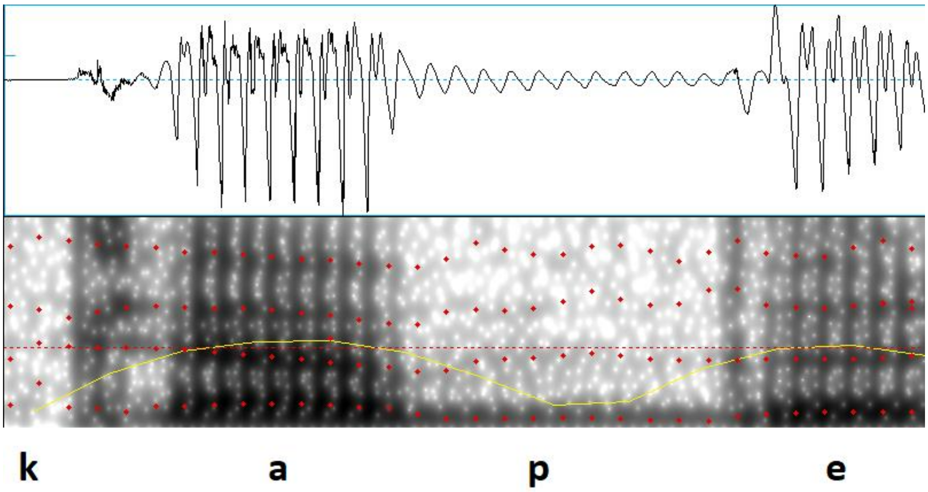

Figure 8: fully voiced /p/ in the sentence *Caperucita y el lobo feroz*.

Voiced%	ptk	bdg		ptk	bdg		ptk	bdg		ptk	bdg
GMN02	25	100	GEB02	42	71	SEB01	28	100	SLB01	43	65
GMN03	55	100	GEB03	32	100	SEB02	25	100	SLB04	18	84
GMN07	30	77	GEB04	37	100	SEB03	19	100	SLB05	19	75
GMN10	35	100	GEB05	22	79	SEB04	26	69	SLB06	35	71
GMN11	24	87	GEB07	33	88	SEB05	21	89	SLB09	22	74
GMN12	48	87	GEB08	14	83	SEB06	29	100	SLB13	46	96
GMN13	32	100	GEB09	34	100	SEB07	24	39	SLB16	33	34
GMN18	24	100	GEB10	28	84	SEB08	16	57	SLB18	27	73

Table 77: percentage of voiced portion per individual in German intervocalic stops.

Finally, relative increases in duration for fortis stops in relation to their lenis counterparts present much interspeaker variability both for Spanish (table 78) and German (table 79). As can be seen, most speakers present greater duration contrasts in Spanish as a result of the presence of the series of lenited /b d g/ into approximants; however, duration contrasts among GMNs do not correlate the presence of approximants in their speech.

SMN03	106	SLB01	141	SEB01	120	GEB02	174
SMN07	156	SLB04	202	SEB02	191	GEB03	145
SMN08	156	SLB05	251	SEB03	168	GEB04	240
SMN10	123	SLB06	232	SEB04	132	GEB05	188
SMN11	185	SLB09	179	SEB05	163	GEB07	211
SMN14	142	SLB13	158	SEB06	155	GEB08	296
SMN15	102	SLB16	151	SEB07	184	GEB09	223
SMN16	186	SLB18	116	SEB08	215	GEB10	161

Table 78: relative duration increases for intervocalic fortis stops per individual in Spanish.

GMN02	194	GEB02	90	SEB01	100	SLB01	75
GMN03	150	GEB03	97	SEB02	81	SLB04	147
GMN07	68	GEB04	85	SEB03	86	SLB05	148
GMN10	81	GEB05	81	SEB04	54	SLB06	96
GMN11	142	GEB07	127	SEB05	103	SLB09	124
GMN12	100	GEB08	97	SEB06	204	SLB13	156
GMN13	86	GEB09	173	SEB07	88	SLB16	96
GMN18	131	GEB10	71	SEB08	139	SLB18	120

Table 79: relative duration increases for intervocalic fortis stops per individual in German.

3.4.3 Fricatives

3.4.3.1 Methodology

Three tokens per fricative phoneme were measured in unstressed and intervocalic position, except for German /ʒ/, from which a single measurement was taken owing to its marginal status in German phonology, and German /x/, which was measured six times, two for each of the three allophonic pronunciations described in Kohler ([2]1995: 160-161): [ç], [x], and [χ]. The sentences used can be consulted in the appendix.

Each token was manually segmented and then acoustically analysed by means of two Praat scripts: one modified by Rentz (2017) for midpoint measurements of the four spectral moments and one developed by Buchholz (2016) for intensity and duration. In addition, the percentage that the voiced portion represents in relation to the whole segment (henceforth %voiced) was also calculated for those consonants. The voiced portion was manually segmented, and its duration was extracted by means of the above-mentioned script for duration, after which percentages were calculated. Spectral moments data will be reported for all fricatives, whereas those for voiced%, intensity and duration only for the German pairs of homorganic fricatives solely distinguished by [± voicing], i.e. /f/ & /v/, /s/ & /z/, /ʃ/ & /ʒ/.

Spectral moment measurements, i.e. COG, SD, skewness, and kurtosis (see 2.1.3 for a description thereof), despite being a useful tool for investigating fricatives, are not exempt from problems owing to the existing large interspeaker variation even among speakers of the same group. Therefore, non-normalised data are not suitable for comparisons when dealing with fricatives. For instance, speaker GMN10 has a COG of 8345 for /s/ and of 6921 for /f/, whereas GMN18 presents considerably lower values (7095 for /s/ and 6341 for /f/). In order to deal with this problem, all data were normalised against speakers' F2 centroid, i.e. their F2 averaged across all stressed vowels (for bilingual speakers, two F2 centroids were calculated, one for each language). COG and SD were simply divided into the speaker's F2 centroid, whereas for skewness and kurtosis the result was then multiplied by 1000 for the sake of easiness when handling the data. Mean groups were calculated for each group, as well as the standard deviation for the monolingual group. Thereafter, monolingual ranges were established on the basis of adding and subtracting 1.5 standard deviations to their mean. All speakers within these ranges are marked in green throughout all values here presented. Finally, the total number of deviations across all fricatives and spectral moments will be quantified in order to use as a variable in 3.4.5 for the correlations between the acoustic data and the global accent ratings.

Being fully aware of the relative arbitrariness of the choice of 1.5 standard deviations, its use was deemed to be appropriate because it is not as narrow as the use of only 1 standard deviation (which would result in many monolinguals deviating from the control group) neither as imprecise as the use of two standard deviations (which would result in many false negatives).

A further argument against the use of only one standard deviation is the large existing individual variation. In this regard, it is worth echoing again Ladefoged & Maddieson's (1996: 137) words noting that "the acoustic structure of fricatives seems to vary widely from individual to individual, but this really reflects only the unfortunate fact that we do not yet know what it is that we ought to be describing". Needless to say, comparing groups and individuals on the basis of their type of bilingualism with monolinguals is especially problematic for a sound class in which the experts conclude that we only have an idea of what we ought to be looking at. Solving the relative lack of knowledge for fricatives is far beyond the scope of this thesis; the use of measurements of the four spectral moments was opted for because, as noted in the literature review, imperfect as it may be, there is wide consensus on its utility. Furthermore, the use of normalised data minimises to a great extent the problem of individual variation.

3.4.3.2 Results

3.4.3.2.1 Spanish Fricatives

/f/

	/f/COG	/f/SDEV	/f/SKEW	/f/KURT
SMN	3.91	2.60	0.55	0.84
SLB	4.28	2.92	0.58	0.79
SEB	3.99	2.65	0.64	0.99
GEB	4.03	2.56	0.52	0.83

Table 80: F2 normalised spectral moments for Spanish /f/ (group means).

The two-tailed Mann-Whitney tests show significant differences between SLBs and the monolinguals for both COG and SD (p = .046 in both cases). However, there is no reason to believe that these differences respond to articulatory differences, since no variant for the voiceless labiodental fricative has ever been described in the literature. As noted before, fricatives are heavily dependent on the speakers' vocal tract; consequently, all values were normalised against the speakers' F2 centroid. Yet, this normalisation procedure has probably some limitations, given that some anatomical differences seemingly persist in the normalised values; SLBs and SMNs not only differ in COG and SD for /f/, but also for /s/ and /θ/, as will be seen later, despite using the same Spanish variety. Likewise, the individual values for speakers SEB02, GEB04, and SLB01, who do not fall within monolingual ranges, are striking, since there no articulatory difference for /f/ has been reported in the literature. As will be seen throughout the results for Spanish fricatives, these three speakers consistently fall outside monolingual ranges. Besides, their F2 centroid is considerably lower than that of the rest of women in the sample because of their deeper pitch, which distorts the normalised value. In sum, their differences are not caused by their bilingual condition, but by the fact of having a pitch lower than typical for women. The rest of the speakers who do not fall within monolingual ranges in only one spectral moment do not deserve much attention, since even monolinguals occasionally deviate for one spectral moment.

	/f/COG	/f/SDEV	/f/SKEW	/f/KURT		/f/COG	/f/SDEV	/f/SKEW	/f/KURT
SMN03	3.60	2.19	0.52	1.06	**SEB01**	3.45	2.32	0.61	0.91
SMN07	3.75	2.48	0.57	0.87	**SEB02**	5.02	3.53	0.95	1.48
SMN08	4.23	2.48	0.45	0.94	**SEB03**	3.72	2.67	0.73	1.15
SMN10	3.66	2.63	0.56	0.72	**SEB04**	4.25	2.73	0.56	0.79
SMN11	3.77	2.89	0.51	0.43	**SEB05**	3.88	2.44	0.58	1.11
SMN14	4.20	2.86	0.60	0.71	**SEB06**	4.43	2.55	0.54	1.06
SMN15	4.16	2.76	0.64	0.97	**SEB07**	3.37	2.39	0.48	0.48
SMN16	3.88	2.49	0.58	0.99	**SEB08**	3.79	2.59	0.65	0.95
SLB01	5.10	3.48	0.69	0.91	**GEB02**	3.93	2.64	0.63	1.05
SLB04	4.47	2.79	0.53	0.80	**GEB03**	3.70	2.45	0.57	0.96
SLB05	3.99	2.83	0.68	1.01	**GEB04**	5.02	3.35	0.80	1.36
SLB06	3.79	3.22	0.61	0.45	**GEB05**	3.56	2.34	0.50	0.82
SLB09	4.39	2.68	0.50	0.79	**GEB07**	4.00	2.34	0.42	0.61
SLB13	4.16	2.64	0.58	1.06	**GEB08**	3.66	2.32	0.44	0.51
SLB16	4.08	2.99	0.65	0.77	**GEB09**	4.21	2.78	0.55	0.79
SLB18	4.27	2.70	0.41	0.54	**GEB10**	4.15	2.25	0.22	0.58

Table 81: F2 normalised spectral moments for Spanish /f/ (individual means).

/s/

	/s/COG	/s/SDEV	/s/SKEW	/s/KURT
SMN	4.18	2.36	0.68	1.55
SLB	4.56	2.64	0.73	1.67
SEB	4.61	2.39	0.54	1.38
GEB	4.60	2.36	0.56	1.52

Table 82: F2 normalised spectral moments for Spanish /s/ (group means).

Statistically, SMNs and SLBs differ in COG (p = .093) and SD (p = .021); SMNs and SEBs in skewness (p = .093); lastly, SMNs and GEBs in COG (p = .016) and skewness (p = .021).

As noted in 2.1.3.1.2, other researchers found acoustic differences between the apical and laminal realisations of /s/, typical from central and northern Spain and America, respectively. It is unclear, however, whether such articulatory difference can account for the differences in here described. According to the literature, most SLBs should pattern with SMNs in producing apical realisations. As noted before, the differences in COG and SD may have more to do with anatomical differences than with articulatory ones. The articulatory difference could be perhaps correlated with skewness, significantly different for both SEBs and GEBs, but not SLBs.

	/s/COG	/s/SDEV	/s/SKEW	/s/KURT		/s/COG	/s/SDEV	/s/SKEW	/s/KURT
SMN03	4.24	2.11	0.67	1.84	**SEB01**	3.64	2.23	0.53	1.02
SMN07	3.80	2.34	0.72	1.43	**SEB02**	6.10	2.98	0.82	2.11
SMN08	4.24	2.60	0.74	1.47	**SEB03**	4.92	2.53	0.45	1.11
SMN10	4.41	2.45	0.73	1.69	**SEB04**	4.94	2.32	0.61	1.69
SMN11	3.89	2.15	0.53	1.33	**SEB05**	4.45	2.41	0.49	1.13
SMN14	4.05	2.38	0.52	1.04	**SEB06**	4.37	2.40	0.57	1.42
SMN15	4.88	2.61	0.75	1.89	**SEB07**	4.17	2.05	0.26	0.86
SMN16	3.97	2.27	0.74	1.76	**SEB08**	4.25	2.19	0.60	1.74
SLB01	5.37	3.09	1.26	3.20	**GEB02**	4.63	2.22	0.62	1.84
SLB04	5.11	2.37	0.39	1.27	**GEB03**	4.40	2.45	0.61	1.38
SLB05	4.41	2.46	0.53	1.41	**GEB04**	5.48	2.79	0.51	1.75
SLB06	3.79	2.70	0.89	1.79	**GEB05**	4.43	2.35	0.61	1.47
SLB09	4.08	2.38	0.65	1.67	**GEB07**	4.61	2.00	0.50	1.58
SLB13	4.43	2.69	0.70	1.39	**GEB08**	4.33	2.14	0.43	1.11
SLB16	4.97	2.74	0.84	1.46	**GEB09**	4.47	2.63	0.58	1.31
SLB18	4.28	2.66	0.56	1.12	**GEB10**	4.49	2.35	0.63	1.72

Table 83: F2 normalised spectral moments for Spanish /s/ (individual means).

At the individual level, the same remarks expressed for speakers GEB04, SLB01, and SEB02 in /f/ are also valid for /s/. For the rest of the speakers, it is also worth noting that there are many more differences between the bilinguals with the Spanish monolinguals than with the German monolinguals (see 3.4.3.2.2), which is difficult to interpret given that there is a controversy of whether German /s/ is apical, as defended by Kohler (^{2}1995: 161), or laminal, as noted in Russ (2010: 73). It is not to be discarded, however, that, contrary to assumed, both realisations coexist in both languages; as they do in English (Ladefoged & Maddieson, 1996: 146). These authors also note that the choice between apical and laminal realisations in languages without such phonological contrast is probably the result of anatomical differences such as “the amount of protuberance of the alveolar ridge and the relation between the lower jaw and the upper teeth”. Thus, both realisations most likely coexist among speakers of the same region for both languages, which, nonetheless, does not deny the existence of strong diatopic tendencies.

/x/

	/x/COG	/x/SDEV	/x/SKEW	/x/KURT
SMN	3.23	2.83	0.83	1.24
SLB	3.53	2.93	0.82	1.23
SEB	3.26	2.91	0.93	1.43
GEB	3.24	2.88	0.97	1.56

Table 84: F2 normalised spectral moments for Spanish /x/ (group means).

As noted in 2.1.3.1.3, it is typical of some Spanish varieties such as Canarian, Colombian or Caribbean dialects to realise this phoneme as [h]. For the sake of comparability, those instances were excluded. Likewise, Spaniards alternate purely fricative realisations in the velar or uvular region for the phoneme /x/, i.e. [χ] or [x], with realisations that are a combination of uvular trilling with friction in the velar or uvular region, i.e. [χ͡ʀ] or [x͡ʀ]. After verifying that such trilling affects the spectral moments, those instances were excluded for the analyses to level out dialectal differences. 58% realisations of the monolingual group had to be excluded, whereas only one single instance per group among GEB and SLB speakers, and two among SEBs. Given that trilled fricatives are probably more natural when the friction takes place in the same region than the trilling, i.e. they are more natural when the friction occurs in the uvular region than in the velum, having excluded trilled fricatives may also have had the effect of excluding many uvular tokens from the SMN sample, which in turn would level out even more dialect differences (uvular realisations are common in central and northern peninsular Spanish but not in America). Lastly, it is also worth briefly departing from the scope of this research to comment in passing by that only four instances of trilled /x/-tokens were recorded among German monolinguals despite their extensive use of uvular realisations, which supports the idea that trilled /x/ tokens amongst Spaniards are not involuntary articulatory deviances, but a sociophonetic trend.

The four spectral moments are very homogeneous across groups (no difference reached significance). At individual level, except for the speakers with deeper voices, only speaker SMN15 departs in COG, which also seemingly reflects an anatomically triggered difference, since she is also very constant in presenting higher COG values across all fricatives.

	/x/COG	/x/SDEV	/x/SKEW	/x/KURT		/x/COG	/x/SDEV	/x/SKEW	/x/KURT
SMN03	3.21	2.50	0.63	0.89	**SEB01**				
SMN07	3.11	2.75	0.77	1.09	**SEB02**	4.13	4.10	1.24	1.69
SMN08	2.83	2.69	0.90	1.51	**SEB03**	3.29	2.77	1.00	1.86
SMN10	3.49	2.98	0.84	1.15	**SEB04**				
SMN11					**SEB05**	2.83	2.49	0.85	1.27
SMN14	3.03	2.73	1.02	1.95	**SEB06**	3.50	2.84	0.73	0.92
SMN15	4.12	3.59	0.85	0.76	**SEB07**	2.74	2.48	0.87	1.48
SMN16	2.81	2.56	0.84	1.31	**SEB08**	3.06	2.76	0.88	1.39
SLB01	4.30	3.54	1.09	1.73	**GEB02**	2.90	2.89	0.99	1.53
SLB04	3.48	3.28	0.80	0.69	**GEB03**				
SLB05	3.59	2.57	0.73	1.26	**GEB04**	3.66	3.41	1.37	2.78
SLB06	3.33	3.15	0.85	0.99	**GEB05**	2.94	2.66	0.92	1.60
SLB09	3.68	2.65	0.54	0.70	**GEB07**	3.48	2.57	0.72	0.92
SLB13	3.19	2.34	0.78	1.69	**GEB08**	2.85	2.49	0.95	1.63
SLB16	3.17	2.99	0.98	1.52	**GEB09**	3.55	3.32	0.82	0.75
SLB18					**GEB10**	3.29	2.78	0.98	1.75

Table 85: F2 normalised spectral moments for Spanish /x/ (individual means).

/θ/

	/θ/COG	/θ/SDEV	/θ/SKEW	/θ/KURT
SMN	3.88	2.73	0.56	0.78
SLB	4.35	3.21	0.61	0.63

Table 86: F2 normalised spectral moments for Spanish /θ/ (group means).

This phoneme is not present in the varieties spoken by SEB and GEB speakers and therefore only a comparison between the SLB and SMN groups was carried out, which reached significance for COG and SD. As noted before, there are reasons to believe that the normalisation process has not filtered all anatomical differences instead of interpreting these differences as correlates of articulatory differences. It is also worth noting that there is a well-known perceptual overlap between /f/ and /θ/ (e.g. Hanulíková & Weber, 2010), which is confirmed in these results.

	/θ/COG	/θ/SDEV	/θ/SKEW	/θ/KURT		/θ/COG	/θ/SDEV	/θ/SKEW	/θ/KURT
SMN03	3.81	2.60	0.45	0.56	**SLB01**	5.35	3.70	0.74	0.92
SMN07	3.84	2.76	0.47	0.49	**SLB04**	4.28	3.04	0.63	0.75
SMN08	3.97	2.80	0.54	0.67	**SLB05**	4.16	3.60	0.55	0.08
SMN10	3.83	2.77	0.67	0.95	**SLB06**				
SMN11	3.61	2.97	0.54	0.35	**SLB09**	3.74	2.63	0.63	0.98
SMN14	3.93	2.79	0.64	0.87	**SLB13**	4.51	3.21	0.51	0.36
SMN15	4.46	2.66	0.64	1.30	**SLB16**	4.04	3.06	0.58	0.69
SMN16	3.56	2.49	0.55	1.03	**SLB18**				

Table 87: F2 normalised spectral moments for Spanish /θ/ (individual means).

At individual level, it is striking that most SLBs deviate from monolinguals for the second spectral moment.

3.4.3.2.2 German fricatives

/f/

	/f/COG	/f/SDEV	/f/SKEW	/f/KURT
GMN	3.55	2.42	0.52	0.65
GEB	3.58	2.30	0.46	0.65
SEB	3.44	2.21	0.51	0.91
SLB	3.62	2.42	0.53	0.81

Table 88: F2 normalised spectral moments for German /f/ (group means).

There are very homogeneous values across groups, which was to be expected given that German and Spanish /f/ are articulatory identical and therefore no phonetic transfer was possible. Indeed, the only statistical difference in the Mann-Whitney tests between the monolinguals and any of the bilinguals is for kurtosis (p = .036) in the SEB group, which nonetheless has most likely a null perceptual effect.

	/f/DUR	/f/INT	/f/%Voiced
GMN	92	54	28
GEB	107	51	22
SEB	116	49	20
SLB	107	50	21

Table 89: duration, intensity, and voiced% for German /f/ (group means).

%voiced for this sound is only 21% for the Spanish late bilinguals, whereas the same group voiced on average 37% of their Spanish /f/. The total or partial voicing of phonologically voiceless sounds is typical of the dialect of these Spanish late bilinguals in intervocalic position. Interestingly, these late bilinguals seem to be aware of the fact that such voicing cannot be transferred into German because of the distinction of homorganic pairs of fricatives in terms of voicing (e.g. /f/ vs /v/). As will be seen later, they also voiced considerably more /s/ in Spanish than in German. On the contrary, both GEBs and SEBs are very constant in their voiced% values for consonants that are present in both languages. Lastly, individual deviations are scarce, and no speaker deviates in three or four spectral moments.

	/f/COG	/f/SDEV	/f/SKEW	/f/KURT		/f/COG	/f/SDEV	/f/SKEW	/f/KURT
GMN02	3.43	2.41	0.53	0.54	**SEB01**	3.25	2.25	0.49	0.47
GMN03	3.18	2.11	0.47	0.50	**SEB02**	3.27	2.34	0.65	1.13
GMN07	3.49	2.45	0.58	0.87	**SEB03**	3.65	2.26	0.54	1.05
GMN10	3.50	2.19	0.50	0.88	**SEB04**	3.77	2.35	0.48	0.74
GMN11	3.43	2.14	0.44	0.65	**SEB05**	3.87	2.23	0.41	0.89
GMN12	3.84	2.68	0.48	0.60	**SEB06**	3.60	2.13	0.39	0.71
GMN13	4.18	3.07	0.60	0.57	**SEB07**	3.29	2.17	0.55	1.08
GMN18	3.35	2.31	0.55	0.63	**SEB08**	2.83	1.96	0.59	1.18
GEB02	3.80	2.30	0.35	0.44	**SLB01**	3.89	2.88	0.56	0.44
GEB03	3.55	2.40	0.55	0.88	**SLB04**	3.95	2.72	0.56	0.65
GEB04	3.48	2.31	0.47	0.66	**SLB05**	3.62	2.25	0.48	0.88
GEB05	3.76	2.44	0.46	0.64	**SLB06**	3.42	2.60	0.58	0.69
GEB07	3.38	2.01	0.36	0.46	**SLB09**	3.71	2.31	0.61	1.18
GEB08	3.11	2.00	0.45	0.59	**SLB13**	3.57	2.18	0.44	0.84
GEB09	3.97	2.68	0.53	0.54	**SLB16**	3.67	2.26	0.33	0.50
GEB10	3.62	2.27	0.53	1.00	**SLB18**	3.11	2.20	0.67	1.31

Table 90: F2 normalised spectral moments for German /f/ (individual means).

/v/

	/v/COG	/v/SDEV	/v/SKEW	/v/KURT
GMN	3.32	2.93	0.06	0.33
GEB	3.44	3.04	0.05	0.20
SEB	3.38	3.03	0.52	0.16
SLB	3.60	3.28	0.52	0.06

Table 91: F2 normalised spectral moments for German /v/ (group means).

Anew, few differences reached statistical significance in the Mann-Whitney tests (two-tailed), namely: skewness (GMN vs SEB; p = .001), and SD and skewness (GMN vs SLB; p = .074 and .001). These differences cannot be explained in terms of phonetic transfer, since /v/ does not form part of the Spanish phonetic inventory, neither as a side effect of voicing, since all bilinguals regularly voiced /v/ tokens. Irrespective of the phonetic source of these differences, their perceptual influence is most likely very limited, if existent at al. It is also worth noting that the phonetic contrast in terms of duration and intensity between this sound and its fortis counterpart, i.e. /f/, is even more robust among SEBs and SLBs than among GMNs and GEBs.

	/v/DUR	/v/INT	/v/%Voiced	/v vs f/ DUR	/v vs f/ INT
GMN	44	64	100	-53%	17%
GEB	51	59	94	-52%	16%
SEB	45	59	97	-61%	20%
SLB	41	60	100	-62%	20%

Table 92: duration, intensity, and voiced% for German /v/ (group means).

	/v/COG	/v/SDEV	/v/SKEW	/v/KURT		/v/COG	/v/SDEV	/v/SKEW	/v/KURT
GMN02	3.46	2.89	0.05	0.25	**SEB01**	3.17	2.96	0.54	0.15
GMN03	2.79	2.54	0.07	0.72	**SEB02**	3.45	3.21	0.54	0.08
GMN07	3.65	3.35	0.04	-0.22	**SEB03**	3.44	2.99	0.48	0.10
GMN10	3.02	2.60	0.06	0.65	**SEB04**	3.17	2.95	0.52	0.17
GMN11	3.14	2.75	0.06	0.27	**SEB05**	3.68	3.13	0.55	0.33
GMN12	3.70	3.24	0.07	0.53	**SEB06**	3.29	3.20	0.54	0.02
GMN13	3.77	3.47	0.06	0.05	**SEB07**	3.27	3.11	0.52	0.02
GMN18	3.07	2.60	0.06	0.39	**SEB08**	3.58	2.64	0.48	0.39
GEB02	3.60	2.79	0.06	0.64	**SLB01**	3.80	3.39	0.47	-0.10
GEB03	4.18	3.64	0.06	-0.03	**SLB04**	3.47	3.07	0.59	0.32
GEB04	2.98	2.73	0.05	0.27	**SLB05**	3.64	3.52	0.41	-0.29
GEB05	3.35	3.27	0.05	-0.13	**SLB06**	3.61	3.31	0.52	-0.05
GEB07	3.36	3.09	0.05	-0.12	**SLB09**	3.60	3.13	0.57	0.32
GEB08	2.77	2.17	0.06	0.61	**SLB13**	3.89	3.66	0.49	-0.13
GEB09	3.74	3.47	0.06	0.05	**SLB16**	3.36	3.03	0.58	0.30
GEB10	3.54	3.16	0.06	0.32	**SLB18**	3.46	3.17	0.51	0.11

Table 93: F2 normalised spectral moments for German /v/ (individual means).

At individual level, it is to be noted that the only speakers who do not fully voiced their /v/ tokens with regularity are SEB05 (73%), GEB08 (76%) and GEB02 (73%).

/s/

Both GMNs and GEBs, on the one hand, and GMNs and SLBs, on the other, differed statistically only for kurtosis (both p = .093; two-tailed Mann-Whitney test), but this sole difference is perceptually irrelevant. As for voicing, it is interesting to note that, analogously to /f/, the SLBs show considerably less voicing for /s/ in Spanish (38%) than in German (25%) (this aspect was interpreted already in the section on /f/).

	/s/COG	/s/SDEV	/s/SKEW	/s/KURT
GMN	4.20	2.08	0.45	1.24
GEB	4.18	1.99	0.50	1.58
SEB	4.05	1.99	0.49	1.46
SLB	4.13	2.09	0.53	1.52

Table 94: F2 normalised spectral moments for German /s/ (group means).

	/s/DUR	/s/INT	/s/%Voiced
GMN	102	55	21
GEB	106	53	21
SEB	104	52	22
SLB	99	50	25

Table 95: duration, intensity, and voiced% for German /s/ (group means).

	/s/COG	/s/SDEV	/s/SKEW	/s/KURT		/s/COG	/s/SDEV	/s/SKEW	/s/KURT
GMN02	4.16	2.04	0.46	1.20	**SEB01**	3.85	1.91	0.20	0.66
GMN03	4.14	1.91	0.29	0.99	**SEB02**	4.09	2.00	0.49	1.50
GMN07	4.10	2.09	0.48	1.43	**SEB03**	4.23	2.08	0.49	1.44
GMN10	4.22	2.21	0.51	1.00	**SEB04**	4.29	1.85	0.47	1.77
GMN11	3.85	1.99	0.33	0.72	**SEB05**	4.15	2.01	0.59	1.95
GMN12	4.69	2.06	0.65	2.52	**SEB06**	4.04	2.02	0.55	1.62
GMN13	4.72	2.39	0.51	1.36	**SEB07**	3.85	2.00	0.62	1.66
GMN18	3.75	1.95	0.34	0.72	**SEB08**	3.88	2.06	0.48	1.07
GEB02	4.27	1.90	0.55	1.87	**SLB01**	4.15	2.35	0.70	1.52
GEB03	4.23	2.29	0.64	1.51	**SLB04**	4.50	1.98	0.43	1.67
GEB04	3.95	2.11	0.51	1.14	**SLB05**	3.74	1.83	0.30	1.08
GEB05	4.36	1.86	0.49	1.97	**SLB06**	3.87	2.05	0.45	1.34
GEB07	4.48	1.72	0.37	1.83	**SLB09**	4.46	2.12	0.47	1.42
GEB08	3.54	1.81	0.48	1.24	**SLB13**	3.89	2.14	0.69	1.81
GEB09	4.36	2.26	0.44	1.20	**SLB16**	4.51	2.12	0.73	2.07
GEB10	4.27	1.96	0.53	1.86	**SLB18**	3.91	2.11	0.48	1.26

Table 96: F2 normalised spectral moments for German /s/ (individual means).

As noted when presenting the results for Spanish /s/, there are fewer deviations between German monolinguals and the bilinguals than between the latter and Spanish monolinguals. It was also noted that the nature of the active articulator for German /s/ is controversial. Kohler defended that it is apical ([2]1995: 161), whilst Russ laminal (2010: 73). In the Spanish literature, it is generally noted that in American Spanish /s/ is laminal, which would explain why SEBs and GEBs resemble much more the German monolinguals than the Spanish ones if we follow Russ in thinking that German /s/ is laminal. However, most SLBs are expected to produce apical contacts because of their dialect and, yet, they also resemble closer the German monolinguals. The individual differences for SLBs are, nonetheless, in skewness, which, as noted in the results for Spanish /s/, might be the acoustic correlate of the articulatory difference. Lastly, it is not to be discarded that spectral moments are not suitable to quantify this articulatory difference.

/z/

	/z/COG	/z/SDEV	/z/SKEW	/z/KURT
GMN	3.91	2.59	0.45	0.55
GEB	3.71	2.69	0.43	0.33
SEB	3.82	2.30	0.48	0.96
SLB	3.92	2.53	0.57	1.05

Table 97: F2 normalised spectral moments for German /z/ (group means).

There are statistical differences (Mann-Whitney test; two-tailed) between the monolinguals and the SLBs in skewness (p = .059) and kurtosis (p = .036). Besides, there are important differences in terms of voicing. Whereas SEBs and SLBs had no problem to voice /v/, applying this feature in the alveolar region seems to be more difficult for them. Additionally, voiceless sounds are naturally longer than their homorganic voiced ones because of the necessary effort to sustain voicing. Thus, there was a domino effect for these two groups and the difference in voicing resulted in a further difference in duration. On the contrary, the fortis vs lenis contrast in the alveolar region in terms of duration and intensity is very similar to the labiodental one in the GMN and GEB groups.

	/z/DUR	/z/INT	/z/%Voiced	/z vs s/ DUR	/z vs s/ INT
GMN	53	63	100	-48%	-15%
GEB	48	63	100	-55%	-19%
SEB	65	58	87	-37%	-12%
SLB	61	58	78	-36%	-14%

Table 98: duration and intensity contrasts between German /z/ (group means) and /s/ & voiced% in /z/.

	/z/COG	/z/SDEV	/z/SKEW	/z/KURT		/z/COG	/z/SDEV	/z/SKEW	/z/KURT
GMN02	3.89	2.32	0.45	0.71	SEB01				
GMN03	4.02	2.31	0.22	0.41	SEB02	4.36	2.37	0.47	1.01
GMN07	3.96	2.82	0.52	0.50	SEB03	3.64	2.61	0.46	0.59
GMN10	3.89	2.16	0.51	1.27	SEB04	3.63	2.23	0.48	1.01
GMN11	3.38	2.16	0.48	0.64	SEB05	4.13	1.98	0.57	1.76
GMN12	4.26	3.20	0.48	0.29	SEB06	3.58	2.74	0.40	0.19
GMN13	4.10	3.21	0.57	0.39	SEB07	3.97	2.07	0.44	1.04
GMN18	3.74	2.56	0.37	0.22	SEB08	3.41	2.09	0.53	1.14
GEB02	3.84	2.64	0.46	0.51	SLB01	3.69	2.03	0.67	1.82
GEB03	4.22	2.87	0.48	0.46	SLB04	3.50	2.87	0.71	0.81
GEB04	3.23	2.92	0.51	0.13	SLB05	4.20	2.33	0.54	1.07
GEB05	3.40	2.07	0.40	0.83	SLB06	4.11	2.85	0.70	0.92
GEB07	4.14	2.36	0.26	0.35	SLB09	4.19	2.36	0.54	1.30
GEB08	3.52	2.62	0.40	0.05	SLB13	4.19	2.00	0.42	1.69
GEB09	3.68	3.08	0.52	0.22	SLB16	3.70	2.67	0.57	0.80
GEB10	3.62	2.98	0.44	0.08	SLB18	3.78	3.15	0.44	0.01

Table 99: F2 normalised spectral moments for German /z/ (individual means).

It is also worth mentioning the large interspeaker variation regarding voicing. For instance, SLB05 (22%) and SLB13 (38%) consistently fail to implement voicing in their phonetic /z/ productions; in addition, SLB01 present significant voiced% levels (65%). On the contrary, the rest of late bilinguals never failed to fully produce voiced /z/ tokens. In turn, among SEBs there are also some cases of incomplete voicing: SEB02 (82%), SEB05 (65%), and SEB07 (60%) (there are no data for SEB01 because she always elided /z/). The rest of the speakers fully voiced their /z/ tokens

/ʃ/

	/ʃ/COG	/ʃ/SDEV	/ʃ/SKEW	/ʃ/KURT
GMN	3.30	2.17	0.82	1.61
GEB	3.23	2.06	0.84	2.00
SEB	3.23	2.01	0.77	1.83
SLB	3.35	2.24	0.86	1.83

Table 100: F2 normalised spectral moments for German /ʃ/ (group means).

None of the small differences observed for /ʃ/ reached significance. At the individual level, the differences are also unimportant, and no speaker deviates across all spectral moments. Regarding voicing, it is worth mentioning that it is seemingly less naturally triggered in this region, since the presence of passive voicing is more reduced for /ʃ/ than for /f/ and /s/ for all groups.

	/ʃ/DUR	/ʃ/INT	/ʃ/%Voiced
GMN	119	55	14
GEB	132	54	17
SEB	139	52	15
SLB	113	50	13

Table 101: duration, intensity, and voiced% for German /ʃ/ (group means).

	/ʃ/COG	/ʃ/SDEV	/ʃ/SKEW	/ʃ/KURT		/ʃ/COG	/ʃ/SDEV	/ʃ/SKEW	/ʃ/KURT
GMN02	3.25	2.21	0.89	1.71	**SEB01**	2.99	1.91	0.65	1.17
GMN03	3.20	1.93	0.73	1.46	**SEB02**	3.47	2.26	0.82	1.65
GMN07	3.13	2.09	0.89	2.14	**SEB03**	3.20	1.97	0.72	1.79
GMN10	3.21	2.34	0.81	1.34	**SEB04**	3.23	1.82	0.73	1.91
GMN11	3.00	1.87	0.66	1.14	**SEB05**	3.21	1.94	0.93	2.67
GMN12	4.05	2.62	0.85	1.54	**SEB06**	3.35	1.99	0.67	1.54
GMN13	3.69	2.43	0.92	2.04	**SEB07**	3.32	2.19	0.81	1.74
GMN18	2.86	1.89	0.76	1.52	**SEB08**	3.10	1.96	0.87	2.16
GEB02	3.16	1.87	0.82	2.35	**SLB01**	3.14	2.10	0.88	2.09
GEB03	3.69	2.53	0.95	1.91	**SLB04**	3.17	1.72	0.68	1.50
GEB04	2.82	1.93	0.74	1.68	**SLB05**	3.32	2.20	0.93	2.11
GEB05	3.21	2.17	0.86	1.85	**SLB06**	3.17	2.40	0.87	1.77
GEB07	3.51	2.02	0.68	1.26	**SLB09**	3.57	2.39	0.88	1.75
GEB08	3.00	1.95	0.66	1.17	**SLB13**	3.68	2.52	0.92	1.76
GEB09	3.43	2.14	0.88	2.16	**SLB16**	3.55	2.27	0.84	1.87
GEB10	2.98	1.84	1.14	3.60	**SLB18**	3.18	2.30	0.92	1.78

Table 102: F2 normalised spectral moments for German /ʃ/ (individual means).

/ʒ/

	/ʒ/COG	/ʒ/SDEV	/ʒ/SKEW	/ʒ/KURT
GMN	3.27	2.65	0.78	1.03
GEB	3.18	2.31	0.78	1.41
SEB	3.10	2.26	0.81	1.50
SLB	3.24	2.36	0.94	1.95

Table 103: F2 normalised spectral moments for German /ʒ/ (group means).

In contrast to its fortis counterpart, some differences reached significance for /ʒ/ in the comparison between bilinguals and monolinguals, namely skewness (p = .009) and kurtosis (p = .012) for the SLBs, and kurtosis for the SEBs (p = .071).

	/ʒ/DUR	/ʒ/INT	/ʒ/%Voiced	/ʒ vs ʃ/ DUR	/ʒ vs ʃ/ INT
GMN	70	61	100	-41%	-9%
GEB	77	55	85	-42%	-2%
SEB	70	58	81	-49%	-12%
SLB	94	51	66	-17%	-2%

Table 104: duration and intensity contrasts between German /ʒ/ (group means) and /ʃ/ & voiced% in /ʒ/.

Besides, the contrast with its fortis counterpart is less robust in terms of intensity for GMNs and SEBs and minimal for GEBs and SLBs. More important are however the differences in terms of voicing. As can be seen in table 104, the only group wherein all participants constantly voiced their /ʒ/ tokens is the monolingual one. As noted for /z/, the differences in voicing resulted in turn in differences in duration. Thus, the fortis vs lenis contrast in the postalveolar region is particularly less robust in the speech of the SLBs than in the rest of the groups.

Group means obscure, however, the fact that there is enormous interspeaker variability in terms of voiced%: GEB03 and GEB10 only voiced 19% and 78% of the segment, respectively; SLB05 and SLB01 present very low voiced averages (9% and 17%) and two other late bilinguals represent an intermediate position (SLB06, 46%, and SLB18, 54%); in turn, SEB01 and SEB06 failed to consistently produce voicing during their tokens. The rest of the speakers produced fully voiced postalveolar fricatives, except for SEB03, SEB07, and GEB08, who produced either affricates or stops.

	/ʒ/COG	/ʒ/SDEV	/ʒ/SKEW	/ʒ/KURT		/ʒ/COG	/ʒ/SDEV	/ʒ/SKEW	/ʒ/KURT
GMN02	3.21	2.58	0.85	1.14	**SEB01**	2.95	2.47	0.76	0.88
GMN03	3.49	2.39	0.82	1.09	**SEB02**	3.09	2.08	0.76	1.64
GMN07	3.13	2.96	0.78	0.77	**SEB03**				
GMN10	2.62	2.25	0.84	1.53	**SEB04**	2.77	1.92	0.83	2.11
GMN11	3.14	2.21	0.74	1.17	**SEB05**	3.66	2.59	0.85	1.25
GMN12	4.04	3.73	0.61	0.02	**SEB06**	3.05	2.39	0.93	1.80
GMN13	3.64	3.06	0.81	0.85	**SEB07**				
GMN18	2.89	2.04	0.82	1.67	**SEB08**	3.09	2.11	0.73	1.34
GEB02	3.12	1.89	0.71	1.91	**SLB01**	3.20	2.66	0.67	0.59
GEB03	3.69	2.36	0.90	1.97	**SLB04**	3.39	2.21	1.06	2.62
GEB04	2.84	2.59	0.69	0.74	**SLB05**	3.08	2.04	0.93	2.14
GEB05	2.58	1.67	0.68	1.56	**SLB06**	2.97	2.46	1.03	2.14
GEB07	3.45	2.28	0.72	1.05	**SLB09**	3.52	2.02	0.91	2.39
GEB08					**SLB13**	3.24	2.65	1.08	2.00
GEB09	3.40	2.88	0.84	1.03	**SLB16**	3.52	2.54	0.89	1.61
GEB10	3.19	2.48	0.94	1.60	**SLB18**	3.02	2.32	0.99	2.09

Table 105: F2 normalised spectral moments for German /ʒ/ (individual means).

For SEBs and SLBs, it is possible to interpret the inefficient implementation of the feature [+voicing] for this phoneme as a sign of the influence of their bilingual condition and more specifically their Spanish dominance in terms of input during childhood. However, particularly in relation to GEB03, it must also be noted that, as noted in Russ (2010: 76) some native speakers produce voiceless tokens instead of [ʒ] as a mark of colloquial speech.

/x/

As noted before, this phoneme has been claimed to have three allophones in complementary distribution (Kohler, ²1995: 160-161): [ç], [x], and [χ]. The normalised values for each allophone will be discussed separately, but in order to test whether these sounds are in complementary distribution, a series of Wilcoxon signed-rank tests were first run. The results in table 106 confirm that three of the four spectral moments are statistically different for each possible combination (uvular vs velar, uvular vs palatal, and velar vs palatal) among monolinguals. GEBs pattern with the monolinguals (indeed, they contrast velar and uvular realisations in the four spectral moments); however, three out of four spectral moments do not differ significantly for SLBs and SEBs for uvular and palatal realisations. To what extent such differences have a perceptual effect is difficult to discuss, but it can be noted that COG is the most important spectral moment in terms of perception and that both groups present significant differences in this regard for uvular and palatal realisations. Thus, it seems that, albeit with some differences, all four groups may present a kind of tri-allophonic contrast for /x/.

Group	χ vs x COG	χ vs x SD	χ vs x SKEW	χ vs x KURT	χ vs ç COG	χ vs ç SD	χ vs ç SKEW	χ v s ç KURT	x vs ç COG	x vs ç SD	x vs ç SKEW	x vs ç KURT
GMN	.018	.018	.128	.018	.063	.043	.237	.018	.263	.012	.012	.012
GEB	.036	.036	.025	.017	.012	.012	.036	.327	.779	.012	.069	.012
SEB	.225	.043	.225	.043	.043	.893	.345	.500	.484	.036	.017	.012
SLB	.401	.093	.036	.017	.012	.401	.575	.889	.017	.050	.093	.017

Table 106: differences between /x/ allophones across groups.

At individual level, no Wilcoxon signed-rank tests could be performed because of the number of observations. Instead, the relative changes in the normalised values for each speaker were calculated between the voiceless uvular and velar fricatives, on the one hand, and between the palatal and velar fricatives, on the other. In order to facilitate the visual interpretation of the individual data, all negative values (i.e. decreases) and positive values (i.e. increases) have been marked in red and green, respectively.

	/χ/ vs /x/					/χ/ vs /x/			
Speaker	COG	SD	SKEW	KURT	Speaker	COG	SD	SKEW	KURT
GMN02	-2	-3	5	22	SEB01	-8	-7	31	2522
GMN03	-20	-22	48	-14137	SEB02	-10	-11	36	4188
GMN07	-3	-4	-5	8	SEB03				-100
GMN10					SEB04				-100
GMN11	-3	-6	14	206	SEB05	9	-5	-9	788
GMN12	-16	-4	63	-223	SEB06	3	-20	-27	1138
GMN13	-11	-26	-10	91	SEB07	-33	-31	85	5810
GMN18	-15	-28	12	197	SEB08				-100
GEB02	-22	-25	65	511	SLB01	-4	-9	41	234
GEB03	-8	1	44	109	SLB04	-1	8	8	-14
GEB04	-21	-22	67	-23539	SLB05	-6	-8	19	77
GEB05	-17	-8	55	175	SLB06	-6	-12	2	26
GEB07	22	8	-12	-40	SLB09	-3	-19	-10	35
GEB08	-19	-24	7	79	SLB13	9	-15	24	140
GEB09	-18	-17	17	143	SLB16	7	12	53	167
GEB10	-20	-18	25	112	SLB18	-17	-16	29	119

Table 107: relative changes for /χ/ vs /x/ tokens per individual.

As can be seen, all monolinguals decrease COG and SD for the uvular allophone in relation to the velar one, but whereas in some cases the difference is of big magnitude (around 15%), in others it is probably perceptually irrelevant (2 or 3%). This may suggest that Kohler's tri-allophonic distribution is probably a reality for most but not all native speakers. It is also worth noting that only SLB18 produces a considerable change in COG among SLBs. Given that retracted vowels such as [ɔ] naturally trigger uvular pronunciations, the lack of distinction of COG for uvular and velar fricatives may be the result of a phonetic difference in vowel production (as noted in 3.4.1.2.2, SLBs and monolinguals did differ for F2 in [ɔ]). Thus, it can be interpreted as a case of a domino effect in pronunciation. In turn, all GEBs clearly contrast between these two sounds, whereas there are mixed results for SEBs.

	/ç/ vs /x/					/ç/ vs /x/			
Speaker	COG	SD	SKEW	KURT	Speaker	COG	SD	SKEW	KURT
GMN02	9	-21	14	136	SEB01	-2	-22	37	3397
GMN03	-15	-40	48	-24896	SEB02	-7	-21	52	6847
GMN07	-9	-32	20	311	SEB03	39	1	7	1141
GMN10	-6	-28	91	-1820	SEB04	8	-24	50	18933
GMN11	8	-28	31	1412	SEB05	41	6	0	825
GMN12	-8	-42	30	-749	SEB06	5	-15	24	2505
GMN13	-7	-24	17	180	SEB07	-6	-15	49	3043
GMN18	7	-28	10	243	SEB08	-5	-39	16	4625
GEB02	3	-29	45	475	SLB01	6	-16	27	177
GEB03	14	-9	19	99	SLB04	3	-18	31	133
GEB04	-12	-40	48	-30541	SLB05	-1	-25	12	121
GEB05	5	-17	27	169	SLB06	4	-19	14	89
GEB07	36	-11	-7	15	SLB09	20	-3	-19	-17
GEB08	-8	-35	-15	83	SLB13	9	-25	-2	105
GEB09	-9	-27	2	151	SLB16	18	5	59	210
GEB10	-2	-24	32	188	SLB18	4	2	20	28

Table 108: relative changes for /ç/ vs /x/ tokens per individual.

There are also notable decreases in COG and SD as well as increases in skewness for /ç/ in relation to /x/ for most GMNs. Particularly relevant from a perceptual perspective seem to be the changes in SD, since it decreases in all GMN and GEB speakers. There are, however, four bilinguals who do not follow this pattern: SLB16, SLB18, SEB05, and SEB03. In sum, it seems both GEBs and GMNs generally present a tri-allophonic distribution for /x/, whereas most SEBs and SLBs generally produce one allophone in the palatal and a second one in the velar/uvular region. In what follows, the normalised data for each allophone are presented alongside the statistical differences between each bilingual group and the monolinguals.

[ç]

	/ç/COG	/ç/SDEV	/ç/SKEW	/ç/KURT
GMN	3.28	2.14	0.74	1.50
GEB	3.22	2.11	0.79	1.74
SEB	3.21	2.21	0.77	1.45
SLB	3.30	2.32	0.82	1.65

Table 109: F2 normalised spectral moments for German /ç/ (group means).

The only statistical difference with monolinguals was produced by the SLBs for SD (p = .074), but, given that it is small and that all other spectral moments go in line with the monolinguals, it seems reasonable to conclude that the SLB group has acquired the target phoneme.

	/ç/DUR	/ç/INT
GMN	97	52
GEB	98	50
SEB	97	52
SLB	100	51

Table 110: duration, intensity, and voiced% for German /ç/ (group means).

	/ç/COG	/ç/SDEV	/ç/SKEW	/ç/KURT		/ç/COG	/ç/SDEV	/ç/SKEW	/ç/KURT
GMN02	3.37	2.15	0.82	1.66	SEB01	2.94	2.12	0.77	1.19
GMN03	3.05	1.84	0.73	1.72	SEB02	3.11	2.52	0.87	1.44
GMN07	2.97	2.19	0.80	1.59	SEB03	3.62	2.15	0.77	1.73
GMN10	3.02	2.17	0.84	1.75	SEB04	3.35	2.26	0.75	1.43
GMN11	3.33	2.09	0.69	1.26	SEB05	3.61	2.44	0.84	1.49
GMN12	3.78	2.09	0.55	1.45	SEB06	3.17	2.25	0.76	1.61
GMN13	3.39	2.57	0.83	1.36	SEB07	2.97	2.26	0.80	1.40
GMN18	3.30	2.01	0.68	1.22	SEB08	2.91	1.71	0.58	1.31
GEB02	3.37	2.17	0.90	2.14	SLB01	2.94	2.10	0.82	1.68
GEB03	3.54	2.47	0.87	1.79	SLB04	3.24	2.25	0.97	2.36
GEB04	2.91	1.79	0.74	1.99	SLB05	3.17	2.06	0.74	1.57
GEB05	3.17	1.97	0.71	1.79	SLB06	3.38	2.32	0.91	2.11
GEB07	3.30	2.06	0.75	1.43	SLB09	3.63	2.46	0.62	0.98
GEB08	2.92	1.80	0.63	1.41	SLB13	3.34	2.21	0.74	1.59
GEB09	3.40	2.49	0.74	1.19	SLB16	3.33	2.41	0.96	1.94
GEB10	3.14	2.14	0.93	2.20	SLB18	3.36	2.76	0.80	1.01

Table 111: F2 normalised spectral moments for German /ç/ (individual means).

[x]

	/x/COG	/x/SDEV	/x/SKEW	/x/KURT
GMN	3.39	3.09	0.58	0.21
GEB	3.16	2.81	0.67	0.65
SEB	2.99	2.67	0.61	0.06
SLB	3.07	2.67	0.70	0.85

Table 112: F2 normalised spectral moments for German /x/ (group means).

All bilingual groups deviated from monolinguals in at least two spectral moments; GEBs in skewness and kurtosis (p = .059 and .027); SEBs in COG and SD (p = .027 and .016); and, lastly, SLBs in COG, SD, skewness, and kurtosis (p = .074, .009, .046, and .002).

	/x/DUR	/x/INT
GMN	53	62
GEB	63	60
SEB	83	53
SLB	92	49

Table 113: duration, intensity, and voiced% for German /x/ (group means).

	/x/COG	/x/SDEV	/x/SKEW	/x/KURT		/x/COG	/x/SDEV	/x/SKEW	/x/KURT
GMN02	3.09	2.71	0.72	0.70	**SEB01**	3.01	2.70	0.56	0.03
GMN03	3.58	3.09	0.49	-0.01	**SEB02**	3.36	3.19	0.57	0.02
GMN07	3.28	3.23	0.67	0.39	**SEB03**	2.60	2.12	0.72	0.14
GMN10	3.20	3.02	0.44	-0.10	**SEB04**	3.10	2.96	0.50	0.01
GMN11	3.10	2.90	0.53	0.08	**SEB05**	2.56	2.31	0.84	0.16
GMN12	4.10	3.60	0.42	-0.22	**SEB06**	3.03	2.65	0.62	0.06
GMN13	3.66	3.36	0.71	0.48	**SEB07**	3.17	2.64	0.54	0.04
GMN18	3.08	2.79	0.62	0.35	**SEB08**	3.06	2.79	0.50	0.03
GEB02	3.29	3.04	0.62	0.37	**SLB01**	2.78	2.50	0.65	0.61
GEB03	3.10	2.72	0.73	0.90	**SLB04**	3.16	2.76	0.74	1.01
GEB04	3.30	3.00	0.50	-0.01	**SLB05**	3.21	2.74	0.66	0.71
GEB05	3.02	2.38	0.56	0.66	**SLB06**	3.26	2.86	0.80	1.12
GEB07	2.43	2.32	0.81	1.25	**SLB09**	3.03	2.53	0.77	1.19
GEB08	3.18	2.78	0.74	0.77	**SLB13**	3.06	2.94	0.75	0.78
GEB09	3.76	3.44	0.73	0.47	**SLB16**	2.82	2.30	0.60	0.63
GEB10	3.19	2.81	0.70	0.76	**SLB18**	3.22	2.70	0.67	0.79

Table 114: F2 normalised spectral moments for German /x/ (individual means).

[χ]

	/χ/COG	/χ/SDEV	/χ/SKEW	/χ/KURT
GMN	3.05	2.69	0.68	0.68
GEB	2.71	2.41	0.88	1.55
SEB	2.76	2.29	0.74	1.32
SLB	2.98	2.46	0.84	1.55

Table 115: F2 normalised spectral moments for German /χ/ (group means).

Finally, no difference was found between SEBs and GMNs. On the contrary, GEBs differed from monolinguals in COG, skewness, and kurtosis (p = .015, .027, and .015), whereas SLBs only in skewness and kurtosis (p = .003 and 0.004).

	/χ/DUR	/χ/INT
GMN	92	56
GEB	112	50
SEB	124	51
SLB	118	47

Table 116: duration, intensity, and voiced% for German /χ/ (group means).

	/χ/COG	/χ/SDEV	/χ/SKEW	/χ/KURT		/χ/COG	/χ/SDEV	/χ/SKEW	/χ/KURT
GMN02	3.02	2.64	0.76	0.86	SEB01	2.76	2.50	0.73	0.89
GMN03	2.85	2.41	0.73	0.97	SEB02	3.03	2.82	0.78	0.89
GMN07	3.19	3.09	0.64	0.42	SEB03				
GMN10					SEB04				
GMN11	3.00	2.72	0.60	0.25	SEB05	2.78	2.19	0.77	1.43
GMN12	3.43	3.46	0.69	0.27	SEB06	3.11	2.11	0.45	0.76
GMN13	3.25	2.50	0.63	0.92	SEB07	2.12	1.83	0.99	2.64
GMN18	2.61	2.02	0.69	1.06	SEB08				
GEB02	2.58	2.29	1.03	2.28	SLB01	2.68	2.26	0.91	2.02
GEB03	2.83	2.74	1.06	1.88	SLB04	3.13	2.99	0.80	0.87
GEB04	2.60	2.33	0.84	1.53	SLB05	3.04	2.52	0.78	1.26
GEB05	2.51	2.18	0.87	1.82	SLB06	3.06	2.52	0.81	1.42
GEB07	2.96	2.49	0.71	0.75	SLB09	2.93	2.05	0.69	1.61
GEB08	2.57	2.12	0.80	1.39	SLB13	3.33	2.49	0.94	1.86
GEB09	3.07	2.86	0.85	1.15	SLB16	3.02	2.57	0.92	1.67
GEB10	2.55	2.30	0.87	1.62	SLB18	2.67	2.27	0.87	1.72

Table 117: F2 normalised spectral moments for German /χ/ (individual means).

3.4.4 Rhotics

3.4.4.1 Methodology

As reviewed in 2.1.4.1, Spanish has two phonemes that can be classified under the label ‘rhotics’. They are phonetically different: one is a tap, whereas the other is a trill. In turn, German has a single rhotic phoneme, which is usually pronounced as a fricative. Consequently, specific acoustic measurements had to be carried out for each rhotic.

For Spanish, 12 tokens were analysed (the sentences used can be consulted in the appendix): 8 taps and 4 trills. Half of the tokens for each sound-class were measured in stressed position and the other half in unstressed position, and all of them intervocalically. For both taps and trills, duration measurements were taken after manual segmentation and by means of a Praat script developed by Buchholz (2016). Furthermore, tap realisations were categorically classified depending on whether they had been produced as alveolar taps [ɾ] or approximant taps [ɾ̞]. On the other hand, trills were categorically classified depending on their number of lingual contacts: from 0 to 3. For a contact to be counted, it was established that it should be clearly visible in the form of a rapid occlusion and not realised in an approximant manner. Thus, those zero-contact trills that are not fricative but do not present a clear occlusion either could arguably be considered by other researchers to have one contact of the approximant type. Similarly, some of the one-contact trills could arguably be regarded as two-contact trills: the first one being clearly visible and the second of an approximant type. This procedure would imply, however, a mixed categorical classification based on both number and type of contacts, which was not deemed as suitable for this sample’s size.

For German, 8 instances of German rhotics, split into stressed and unstressed position and always in intervocalically, were analysed. Anew, these realisations were manually segmented and categorically classified depending on their phonetic realisations found in the sample, namely: elisions, alveolar trills, alveolar taps, uvular approximants, and uvular fricatives. Additionally, uvular fricative realisations were acoustically analysed by means of a Praat script modified by Rentz (2017) that calculates the four spectral moments.

3.4.4.2 Results

3.4.4.2.1 Spanish rhotics

The number of lingual contacts per phonological trill varies across groups (table 118). The monolingual group presents the highest mean, with 1.69 contacts, which fits perfectly with the data reviewed in table 19. Those data indicate that the number of lingual contacts per trill increases as one heads northwards; with 1.13 contacts per trill, Andalusian occupies one extreme of the continuum, whereas on the other side northern Castilians produce 2.18 contacts (Henriksen & Willis, 2010); in between speakers of southern Castilian produce intermediate values: 1.51 in Roller (2011) and 1.56 in Henriksen (2014); finally, this sample of central Spanish speakers produced trills with 1.69 contacts. Thus, the number of lingual contacts seems to be particularly sensitive to diatopic variation. In addition, there is large interspeaker variation within groups (table 119). A battery of Mann-Whitney tests revealed that group differences are only significant between SMNs and SLBs (p = .014 two-tailed).

Group	Mean (SD)
SMN	1.69 (0.64)
SLB	1.22 (0.75)
SEB	1.35 (0.95)
GEB	1.4 (0.77)

Table 118: mean number and SD of lingual contacts per phonological trill.

Speaker	Mean	SD	Speaker	Mean	SD	Speaker	Mean	SD	Speaker	Mean	SD
SMN03	2	0.82	SLB01	1	0.82	SEB01	1.75	1.26	GEB02	1.25	0.96
SMN07	2.25	0.96	SLB04	1.25	0.50	SEB02	2.25	0.50	GEB03	1.25	0.96
SMN08	1.5	0.58	SLB05	1.5	0.58	SEB03	0.75	0.50	GEB04	1	0.00
SMN10	1.5	0.58	SLB06	1	0.82	SEB04	1.75	0.50	GEB05	1	0.00
SMN11	1.25	0.50	SLB09	1.25	0.96	SEB05	2.25	0.50	GEB07	1	0.82
SMN14	1.75	0.50	SLB13	2	0.82	SEB06	0.67	0.58	GEB08	2	1.16
SMN15	1.75	0.50	SLB16	1.25	0.50	SEB07	0.5	0.58	GEB09	1.75	0.50
SMN16	1.5	0.58	SLB18	0.5	0.58	SEB08	0.75	0.96	GEB10	1.75	0.50

Table 119: mean number and SD of lingual contacts per phonological trill and individual.

As expected, the lowest standard deviation corresponds to the monolinguals, i.e. they are the most homogeneous group. This is further corroborated by fact that one- and two-contact trills account for more than 90% of the total in this group (table 120). Nonetheless, great variability is the norm across groups; the mode does not account for more than 50% in any group. It is also worth mentioning that traditionally assumed non-canonical trills, i.e. those without multiple vibrations, represent 40.6% of the monolingual group productions, whereas the bilinguals produced more than the half of their productions in a non-canonical fashion.

GROUP	Type of trill	%	GROUP	Type of trill	%
SMN	1-contact trill	40.6	SEB	0-contact trill	22.6
	2-contact trill	**50**		1-contact trill	29
	3-contact trill	9.4		**2-contact trill**	**38.7**
SLB	0-contact trill	12.5		3-contact trill	9.7
	1-contact trill	**50**	GEB	0-contact trill	10
	2-contact trill	31.3		**1-contact trill**	**46.7**
	3-contact trill	3.1		2-contact trill	36.7
	elision	3.1		3-contact trill	6.7

Table 120: distribution of possible realisations for phonological trills across groups. Mode **in bold**.

Likewise, there is also a great deal of variation for the phonological tap (table 121). Excluding a single token in the GEB group which was erroneously produced with an alveolar trill, there are two main phonetic variants of the phonological tap: the canonical one, which is produced with an actual tap, and an approximant variant in which there is a clear decay in intensity, but during which no occlusion is visible. Furthermore, two more options were included in the study despite their marginal occurrence: elision and perceptual tap. Following Bradley & Willis (2012), those cases in which a tap is present in the acoustic signal and yet its delimitation by means of objective acoustic clues is impossible were marked as perceptual taps.

Interestingly, nobody from the group of GEBs transferred a uvular pronunciation from German into Spanish and, in contrast to trills, the monolinguals did not produce the highest number of canonical taps, i.e. with an actual tap instead of a fricative or approximant realisation. Whereas they tend to produce approximant realisations more often than not (67.2%), GEBs quite consistently present canonical taps (78.1%). The other two groups of bilinguals present a slight tendency for one variant, but mostly produce taps and approximant taps in the same proportion.

GROUP	Type of tap	%	Frequency	GROUP	Type of tap	%	Frequency
GEB	alveolar trill	1.6	1	SLB	elision	1.6	1
	approximant tap	20.3	13		perceptual tap	3.1	2
	tap	**78.1**	50		approximant tap	**51.6**	33
SEB	elision	1.6	1		tap	43.8	28
	approximant tap	46.9	30	SMN	approximant tap	**67.2**	43
	tap	**51.6**	33		tap	32.8	21

Table 121: distribution of possible realisations for phonological taps across groups. Mode **in bold**.

As reviewed in 2.1.4.1, it has been claimed that the contrast between taps and trills, although potentially jeopardised when trills are produced with a single contact (the canonical form of a tap is precisely one single contact), is maintained by means of duration. In order to test the validity of this assessment, segment durations for the main different phonetic realisations of both taps (table 122) and trills (table 123) are given. Finally, table 124 provides mean durations for phonological taps and trills irrespective of the phonetic nature of the segment.

Group	Type of tap	Mean	SD	Group	Type of tap	Mean	SD
SMN	approximant tap	17	6	SEB	approximant tap	18	6
	tap	27	10		tap	29	9
SLB	approximant tap	20	6	GEB	approximant tap	16	4
	tap	29	8		tap	32	11

Table 122: mean duration and SD (in ms) per group and phonetic realisation of the phonological tap.

Group	Contacts	Mean	SD	Group	Contacts	Mean	SD
SMN	0	--	--	SEB	0	32	20
	1	48	13		1	47	17
	2	54	7		2	58	7
	3	78	10		3	89	10
SLB	0	36	22	GEB	0	53	17
	1	43	12		1	42	16
	2	58	15		2	60	9
	3	81	0		3	80	33

Table 123: mean duration and SD (in ms) per group and phonetic realisation of the phonological trill.

Group	TAP Mean (SD)	TRILL Mean (SD)	Diff. Trill-Tap
SMN	20 (8)	54 (13)	34
SLB	24 (9)	48 (17)	24
SEB	24 (9)	52 (21)	28
GEB	29 (12)	52 (18)	23

Table 124: Mean duration for phonological taps and trills irrespective of their phonetic nature.

As shown in table 124, when all phonetic realisations are taken into account, the contrast between trills and taps is well preserved by means of duration. Indeed, duration for taps and trills is significantly different for all groups (Wilcoxon signed ranks tests; p <.0005). This contrast is nonetheless compromised when comparing canonical taps with one-contact trills. This holds particularly true for the GEBs, for whom the one-contact trill is only 10 ms longer than the canonical tap with one contact. Such a small contrast, albeit statistically significant for all groups (Wilcoxon signed ranks tests; p <.0005) does not seem to be very safe in terms of perception. The difference is slightly longer for SEBs (18 ms), SLBs (14 ms), and double for SMNs (21 ms). Nonetheless, it must be reminded again that the contrast is only jeopardised in the worst-case scenario, since all groups also produce trills with more contacts and approximant taps that enlarge the contrast in duration (the mean duration values irrespective of the phonetic nature of the phonological trills and taps are given in table 126). It is also worth noting that no differences in intensity were found between one-contact trills and canonical taps.

Group	Segment	Mean (SD)
SMN	1-contact trill	62 (7)
	tap	59 (7)
SLB	1-contact trill	59 (7)
	tap	62 (6)
SEB	1-contact trill	63 (2)
	tap	63 (6)
GEB	1-contact trill	62 (7)
	tap	61 (8)

Table 125: mean intensity for 1-contact trills and canonical taps.

In sum, all groups keep two separate rhotic phonemes, but the contrast is more robust in terms of duration among monolinguals than among bilinguals (table 126). The differences, however, cannot be attributed to their bilingualism, but rather to diatopic and individual differences. At the individual level, SLB09 and GEB05 have neutralised the contrast between /ɾ/ and /r/ in terms of duration, whereas for SEB07, SEB08, and GEB09 the contrast is severely compromised.

Speaker	Ms.	Speaker	Ms.	Speaker	Ms.	Speaker	Ms.
SMN03	46	SLB01	41	SEB01	41	GEB02	39
SMN07	45	SLB04	19	SEB02	43	GEB03	18
SMN08	36	SLB05	19	SEB03	28	GEB04	15
SMN10	30	SLB06	26	SEB04	26	GEB05	-3
SMN11	31	SLB09	4	SEB05	37	GEB07	25
SMN14	26	SLB13	37	SEB06	20	GEB08	34
SMN15	25	SLB16	23	SEB07	14	GEB09	13
SMN16	46	SLB18	27	SEB08	12	GEB10	44

Table 126: differences in duration between phonological trills and taps per speaker.

3.4.4.2.2 German Rhotics

The frequency across groups of all possible phonetic realisations for German /ʁ/ is presented in table 127. The uvular fricative realisation, [ʁ], is the most common one among speakers of all groups, albeit with different intensities. The second most widespread realisation is [ʁ̞] (a uvular approximant). Among

GMNs and GEBs, only two abnormal realisations were found. One is an alveolar tap that corresponds to a mispronunciation of the German name *Maria* (confounded with Spanish *María*); the other is an elision. On the contrary, SEBS and SLBs present a wider range of phonetic realisations because of Spanish interferences (alveolar taps, alveolar approximants, and alveolar trills). The other divergent realisation is one case of what seems to be a one-contact uvular trill and a voiced stop, either velar or uvular. Spanish-influenced realisations amount up to 38% and 32% for the SLB and SEB groups (indeed, group differences are highly significant; Pearson's Chi-squared $p < 0.005$), which contrasts with the absence of German-influenced rhotic realisations in the Spanish of GEB speakers.

GROUP	Type of /ʁ/	%	GROUP	Type of /ʁ/	%
GMN	elision	1.6	GEB	alveolar tap	1.6
	uvular approx.	27.4		uvular approx.	32.8
	uvular fricative	**71**		**uvular fricative**	**65.6**
SEB	alveolar approx.	8	SLB	alveolar approx.	10
	alveolar tap	19		alveolar tap	25.4
	alveolar trill	3.2		alveolar trill	1.6
	uvular trill	1.6		voiced stop	1.6
	uvular approx.	30.2		uvular approx.	20.6
	uvular fricative	**38.1**		**uvular fricative**	**41.3**

Table 127: distribution of possible realisations for German /ʁ/ in intervocalic position across groups (mode **in bold)**.

For the sake of comparability, only uvular fricatives have been included in the phonetic analysis, which is carried out for the purpose of investigating whether the phonologically target-like sounds produced by the bilinguals and the monolingual presented the same acoustic properties. Following the same procedure employed for fricatives (3.4.2.3), the four spectral moments were calculated (table 128). Group differences are negligible given the sensitivity of fricatives to individual characteristics, i.e. all bilingual groups are capable of producing target-like tokens.

Group	Spectral Moment	Mean	Group	Spectral Moment	Mean
GMN	COG	5807 (632)	SEB	COG	5590 (851)
	SDEV	5046 (831)		SDEV	5428 (958)
	SKEW	1.09 (0.29)		SKEW	1.07 (0.35)
	KURT	0.79 (1.03)		KURT	0.62 (1.31)
GEB	COG	5827 (630)	SLB	COG	5782 (744)
	SDEV	5176 (678)		SDEV	5008 (854)
	SKEW	1.20 (0.28)		SKEW	1.30 (0.33)
	KURT	1.10 (1.11)		KUR	1.71 (1.50)

Table 128: spectral moments of [ʁ] realisations.

In addition, these values can be compared with those reported for [χ], since this sound is its voiceless counterpart. Except for COG, they largely follow the expected pattern after those found for other German fortis vs lenis fricative pairs, i.e. changes in skewness are very modest, kurtosis decreases, and the SD increases. Normally there is also a mild decrease for COG in the voiced member of these pairs;

however, all [ʁ] items measured were taken in contact with palatal vowels, whereas with retracted ones for [χ], which explains the differences in COG.

At the individual level, the proportion of all uvular and all alveolar realisations, irrespective of their actual manner of articulation, was also calculated (table 129). The rationale behind this procedure is that all uvular realisations are acceptable and common among monolinguals in this German variety; in turn, all alveolar realisations are Spanish transfers.

Speak.	Seg.	%	Speak.	Seg.	%	Speak.	Seg.	%	Speak.	Seg.	%
GMN02	Alv.	0	GEB02	Alv.	0	SLB01	Alv.	25	SEB01	Alv.	0
	Uvu.	100		Uvu.	100		Uvu.	75		Uvu.	100
GMN03	Alv.	0	GEB03	Alv.	0	SLB04	Alv.	87.5	SEB02	Alv.	0
	Uvu.	100		Uvu.	100		Uvu.	12.5		Uvu.	100
GMN07	Alv.	0	GEB04	Alv.	0	SLB05	Alv.	50	SEB03	Alv.	0
	Uvu.	100		Uvu.	100		Uvu.	50		Uvu.	100
GMN10	Alv.	0	GEB05	Alv.	0	SLB06	Alv.	0	SEB04	Alv.	12.5
	Uvu.	87.5		Uvu.	100		Uvu.	100		Uvu.	87.5
GMN11	Alv.	0	GEB07	Alv.	0	SLB09	Alv.	0	SEB05	Alv.	100
	Uvu.	100		Uvu.	100		Uvu.	100		Uvu.	0
GMN12	Alv.	0	GEB08	Alv.	0	SLB13	Alv.	75	SEB06	Alv.	12.5
	Uvu.	100		Uvu.	100		Uvu.	25		Uvu.	87.5
GMN13	Alv.	0	GEB09	Alv.	0	SLB16	Alv.	25	SEB07	Alv.	85.7
	Uvu.	100		Uvu.	100		Uvu.	75		Uvu.	14.3
GMN18	Alv.	0	GEB10	Alv.	12.5	SLB18	Alv.	37.5	SEB08	Alv.	37.5
	Uvu.	100		Uvu.	87.5		Uvu.	62.5		Uvu.	62.5

Table 129: proportion of alveolar (non-target like) and uvular (target-like) realisations per speaker in German.

As shown in table 129, GEB speakers are identical to GMN ones; besides, five SEB and two SLB speakers (SEB01, SEB02, SEB03, SEB04, SEB06, SLB06, and SLB09) perform within monolingual standards. Others are quite close but still display considerable transfer from Spanish (SLB13, SLB16).

3.4.5 Correlations with global accent

The final part of experiment 2 aimed to investigate which acoustic parameters best correlate with the global accent ratings from experiment 1. Logically, since different measurements were taken for each language because of their different phonetic inventories, the variables used for each language are not the same.

Firstly, all variables were converted into z-scores to minimise the effect of having used different units of measurement for each variable (percentages, milliseconds, hertz, etc); secondly, Spearman's rank correlations were calculated; thirdly, a regression analysis was conducted using as predictors only those variables that had reached significance. This procedure was twice followed, once including the SLBs and once without them. The rationale behind that is that, although the results of the statistical analyses wherein they were included are definitely interesting, for the sake of comparability it was also necessary to exclude them in order to determine what factors best predict global accent scores when working only with heritage language speakers.

This section is thus subdivided into 3.4.5.1 (correlations with Spanish global accent task), and 3.4.5.2 (correlations with German global accent task), but before entering into the details, it is worth highlighting that the correlations reported here cannot be interpreted as proofs that these variables are more important to discriminate between native and non-native speech in the general population because, as will be seen later, some variables only correlate when the late bilinguals are included. In other words, what phonetic aspects best correlate with global accent will be heavily determined by the specific characteristic of the bilinguals being sampled, as one phonetic characteristic may be very useful to distinguish beginners from intermediate level students, but not between proficient and native speakers. Thus, the results here reported can only be extrapolated to bilinguals of similar characteristics.

3.4.5.1 Correlations with Spanish global accent

As reported throughout 3.4.1 to 3.4.4, many acoustic measurements were taken for each speaker. Ten of them were selected for the statistical analysis as possible explanatory variables for the Spanish global accent rating (the dependent variable).

Variable 1	/e/ vs /a/ F1+F2 changes
Variable 2	/i/ vs /e/ F1+F2 changes
Variable 3	/u/ vs /o/ F1+F2 changes
Variable 4	/o/ vs /a/ F1+F2 changes
Variable 5	Proportion of non-canonical absolute initial /b d g// tokens
Variable 6	VOT for absolute initial fortis stops
Variable 7	VOT for intervocalic fortis stops
Variable 8	Number of deviant spectral moments across fricatives
Variable 9	Duration difference between phonological trills and taps
Variable 10	All segments duration
Dependent Variable	Spanish global accent score

Table 130: variables for correlations with Spanish global accent score.

All variables except for variable 10 have been presented throughout the respective sections and need therefore no further explanation. Variable 10, in turn, is an indirect measurement for speech rate. Since this aspect most likely affects global accent ratings but this research was restricted to segmental phonetics, this variable was created by summing up the mean duration of the four types of sounds here measured, i.e. all vowels, fricatives, and rhotics measured, and all intervocalic stops (the closure part is not visible in absolute initial position and therefore cannot be measured).

Global Accent	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
Correlation Coefficient	0.121	0.289	0.302	0.125	0.215	0.068	-0.021	0.097	-0.282	0.579
Sig. (2-tailed)	0.510	0.108	0.099	0.504	0.237	0.710	0.909	0.597	0.117	0.001

Table 131: significant values for correlations between Spanish global accent and acoustic variables including SLBs.

Global Accent	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10
Correlation Coefficient	0.164	0.247	0.315	0.188	0.281	0.074	0.275	0.235	-0.262	0.595
Sig. (2-tailed)	0.445	0.245	0.144	0.390	0.183	0.730	0.193	0.268	0.217	0.002

Table 132: significant values for correlations between Spanish global accent and acoustic variables excluding SLBs.

When including SLBs, only variables 3 and 10 correlated significantly with global accent, whereas only variable 10 was still significant after excluding them. It is also important to bear in mind that the effect of these two variables is not equally important. It is common practice to 'translate' the correlation coefficients into categorical types of correlations[15]. Following this practice, the effect of V3 can be classified as weak, whereas that of V10 as moderate (between 0.6 and 0.79 would be considered as strong).

Finally, two regression analyses were performed: one V3 and V10 as predictors and with the SLBs, and one excluding them and with only V10 as predictor. For the former, the two predictors reached an R square of 0.438, i.e. 43.8% of the variation found in the Spanish global accent can be potentially predicted by the combined effect of these two variables. However, the standard error of the estimate is very high. In turn, the potential of V10 to predict variation in Spanish global accent when the SLBs are excluded does not decrease much (37.9%), although again, the standard error of the estimate is very large. Since SLBs are phonetically very similar to monolinguals, it is not surprising to find minor differences between the two analyses.

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.661	0.438	0.397	0.789

Table 133: regression analysis for Spanish Global accent including SLBs.

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.616	0.379	0.351	0.796

Table 134: regression analysis for Spanish Global accent excluding SLBs.

3.4.5.2 Correlations with German global accent

Following the procedure described for Spanish, among all the acoustic measurements taken, eleven of them were chosen for the statistical analysis as possible explanatory variables for the German global accent rating (the dependent variable). All these chosen variables have also been described in the respective sections except for variable 11, which is also the sum of four values: mean duration for vowels, stops, fricatives, and rhotics. For the calculus of mean vowel duration, only lax vowels were

[15] http://www.statstutor.ac.uk/resources/uploaded/spearmans.pdf

included. The rationale behind that is that duration values are being used as an indirect measurement for speech rate and that monolinguals typically speak faster than late bilinguals; however, this indirect way to study speech rate would be distorted if tense vowels were used, since they are typically longer in the speech of monolinguals.

Variable 1	F3 changes in rounded vs unrounded vowels
Variable 2	Sum of F1 and F2 changes (absolute numbers) in tense vs lax counterparts
Variable 3	Duration changes in tense vs lenis vowels
Variable 4	Proportion of non-canonical /b d g/ tokens in terms of voicing in absolute initial position
Variable 5	Fortis minus Lenis VOT in absolute initial position
Variable 6	Proportion of approximant /b d g/ tokens in intervocalic position
Variable 7	VOT for fortis intervocalic stops
Variable 8	Proportion of uvular rhotic realisations
Variable 9	Percentage of voicing during voiced fricatives
Variable 10	Number of deviant spectral moments across fricatives
Variable 11	All segments duration
Dependent variable	German global accent score

Table 135: variables for correlations with German global accent score.

Spearman's rank correlations yielded significant values for V2, V4, V5, V7, V8, V9, V10, and V11 when the SLBs are included. As can be seen, at least one variable involving each sound of class reached significance as well as V11, the means used to indirectly measure speech rate. Following the procedure in 3.4.5.1, the effect of the correlation for V2 when SLBs are included can be classified as strong, whilst those for the rest of variables as moderate.

Global Accent	**V1**	**V2**	**V3**	**V4**	**V5**	**V6**	**V7**	**V8**	**V9**	**V10**	**V11**
Correlation Coefficient	0.206	-0.630	-0.263	0.538	-0.532	0.230	-0.421	-0.403	-0.514	0.460	0.494
Sig. (2-tailed)	.259	.000	.146	.001	.002	.206	.016	.022	.003	.008	.004

Table 136: significant values for correlations between German global accent and acoustic variables including SLBs.

On the contrary, V2 is not even significant when the SLBs are excluded. Likewise, V5 and V10 do not reach significance without the late bilinguals. On the contrary, V1 gains significance, whereas and V4, V7, V8, V9, and V11 keep it. The effect of these variables also differs depending on the inclusion of the late bilinguals. Whereas V11 is the variable whose correlation is stronger when they are excluded, formant structure for tense and lax vowels is considerably more important when they are included. As noted in the introduction for this subsection, the potential as predictor of any acoustic measurement heavily depends on the profiles of the speakers selected. Formant structure can be very useful to explain differences in global accent between monolinguals and highly proficient L2 speakers, but it is not useful at all when trying to predict differences between monolinguals and early bilinguals.

Global Accent	V1	V2	V3	V4	V5	V6	V7	V8	V9	V10	V11
Correlation Coefficient	0.373	-0.261	-0.025	0.356	-0.039	0.028	-0.370	-0.429	-0.365	0.306	0.608
Sig. (2-tailed)	.072	.219	.908	.088	.861	.895	.075	.036	.080	.145	.002

Table 137: significant values for correlations between German global accent and acoustic variables excluding SLBs.

Once the significantly different variables had been identified, two regression analyses were carried out. Contrary to the results in Spanish, the differences in the predicting potential of the significant variables are enormous depending on whether the SLBs are included or not. This can be explained by the fact that no GLB was sampled and that SLBs were monolingually brought up in Spanish and only learnt German in adulthood. The huge difference in R square between the two regression analyses is a sign of the robust potential of segmental phonetics to predict global accent ratings (85.4% of the total variation in this research) when non-native speakers are included, even if they are highly proficient as these SLBs.

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.924	0.854	0.808	0.419

Table 138: regression analysis for German global accent including SLBs.

R	R Square	Adjusted R Square	Std. Error of the Estimate
0.649	0.422	0.217	0.885

Table 139: regression analysis for German global accent excluding SLBs.

3.5 Global discussion

This section does not aim to provide a detailed discussion of the differences among bilinguals and monolinguals for each sound class, which has already been done in the respective subsections across 3.4, but globally discuss all the differences across groups.

Throughout this section, a model of phonetic acquisition valid for both early and late bilingualism is proposed based on my own findings and those reviewed in 2.2. More details about this model will be given throughout this section, but for the sake of clarity it is worth highlighting some of facts on which it is based at the beginning of this section in order to frame the discussion.

This model aims to fit together all the pieces that form the puzzle of phonetic acquisition: the data on bilingual phonetic learnability, the data on L1 attrition, and the data on children with delayed linguistic acquisition. From the literature review emerges a panorama in which several important points must be highlighted:

1) Research on feral children seemingly indicates that our brain is better prepared for language acquisition during some time in childhood. In addition, even slight delays in language acquisition have an impact on the linguistic outcome (Bylung et al., 2012).
2) The only evidence against the existence of age-effects for phonetic acquisition that cannot be overcome is some individuals who are commonly known as “exceptional learners”. There are,

however, good reasons to reject this evidence: a) only very short excerpts of recordings were used in these studies (usually 30 seconds long), from which it cannot be concluded at all that these speakers have the ability to pronounce native-like without monitoring their speech and for extended periods of times; and b) those speakers were not acoustically analysed to check whether they really did not differ from monolinguals. Such allegedly exceptional learners have been reported in Ioup et al. (1994); Molnár (2010); Muñoz & Singleton (2007); Nikolo (2000); Hopp & Schmid (2013); and Bongaerts et al., (1995, 1997, and 2000); see again 2.2.1 for a review and methodological objections to this kind of evidence.

3) Why age of acquisition is such a powerful predictor is still investigated. Both maturational constraints and linguistic entrenchment have been proposed as the major cause (see 2.2.1.1 and 2.2.1.2).
4) L1 can be totally forgotten before puberty (Schmid et al., 2012; Schmid & Dusseldorp, 2010; and Hyltenstam et al., 2009), but even after prolonged periods of time with virtually no use the language is astonishingly well preserved in late bilinguals (Schmid, 2010; and Köpke 2004a for an extensive review).
5) A considerable number of speakers who began acquiring their L2 at very early ages conserved a foreign accent, even when residing in the country where the L2 is spoken (Abrahamsson & Hyltenstam, 2009; and Asher & García, 1969; and Flege et al., 1997). Likewise, many simultaneous bilinguals (most in Kupisch et al., 2014) cannot pass for natives in their heritage language.
6) No clear cut-point (i.e. no “critical” moment) after which native-like pronunciation is impossible has been found. For pronunciation, it has been proposed that after age 6 the possibilities of having a native-like accent drop considerably, and between ages 6 and 12 they keep on decreasing (Granena & Long, 2013). Even admitting that individuals have different maturational rhythms, ranges as wide as those of 0-6 and 6-12 are impossible to reconcile with a critical moment *stricto sensu*; thus, should these maturational constraints do exist, they would be necessarily gradual.
7) Whereas all monolinguals sound native-like (unless they have suffered an injury), there are huge differences among individuals with similar or equal ages of acquisition and amounts of input.

Points number 1 and 2 seemingly indicate that some sort of maturational changes take place in our brain during childhood; based on point 6, it can be inferred that, if those changes do take place, they must be gradual in nature; points 5 and 7 show the need of viewing linguistic acquisition as a complex multifactorial phenomenon in which several variables (e.g. age of acquisition, amount of input, language aptitude, and language attitude) can be combined to form many linguistic profiles. Thus, in a multifactorial linguistic acquisition framework, gradience in L2 learnability is not only unproblematic, but rather the expected scenario because of the multiple possible combinations between all variables at play.

In what follows, the global accent results will be discussed in light of the above-explained theoretical framework. Secondly, the acoustic results will be incorporated into the discussion. Lastly, it will be analysed whether there are discrepancies between the perceived accent (global accent scores) and the findings in the acoustic measurements.

Regarding age and global accent ratings, there are several aspects to discuss. Firstly, none of the late bilinguals here analysed can be classified as an exceptional learner, which goes in line with the vast evidence in the literature that signals that no matter how proficient speakers are in other linguistic domains, they typically and unequivocally score far from monolingual ranges. In turn, despite having been exposed to her L2 only in adulthood, one of these late bilinguals has clear signs of L1 language attrition. She scored 3.29 on global Spanish accent, falling so in the lowest possible range, i.e. “this person is definitely not native”. To put this score in perspective, it is interesting to note that the best score for German among late bilinguals was 3.18.

The early bilinguals in this study cannot tell us anything about the exact age at which pronunciation acquisition is hindered, since, except for two very early bilinguals in each group, all of them are simultaneous bilinguals. They provide, however, clear evidence that acquisition since birth is no guarantee at all to develop a native-like accent and that a critical mass of input is also required.

The impact of the societal language during childhood turned out to be extremely potent to predict the phonetic outcome for simultaneous bilinguals. All SEBs passed for natives in Spanish, whilst all GEBs passed for natives in German. However, only 4 out 8 SEBs, and 5 out of 8 GEBs passed for natives in their heritage language. The input and use opportunities for societal languages are so vast that not sounding native-like is seemingly impossible for simultaneous bilinguals. There are, however, some differences in the scores at group level. German monolinguals scored 1.12 on the global accent task, whereas GEBs 1.25, which is nonetheless statistically not significant (perhaps as a result of the sample size). In turn, SMNs and SEBs did statistically differ, but this result is not comparable to that of German for two reasons: firstly, unlike GMNs and GEBs, these speakers were not homogeneous in terms of the variety spoken (most raters were presumably not familiar with, for instance, Panamanian or Bolivian); and secondly, the SEBs were tested while residing in Germany. Despite that, all SEBs were perceived as natives, although with different degrees of certainty. The doubts cast on their nativeness by some raters most likely also reflect cases of language attrition (albeit not as severe as that described for the attrited late bilingual).

The amount of input is not always as vast as in the case of societal languages and it would be therefore desirable to develop accurate ways to quantify it. This holds particularly true for the study of heritage language acquisition in simultaneous bilinguals. As noted before, only roughly half of the early bilinguals were perceived as natives (which does not equal to receiving the same scores than monolinguals) in their heritage languages. Flege (2007: 376) has noted that "until researchers can find precise ways to quantify the overall amount –and quality– of L2 input, the relative importance of input in comparison to other factors […] will remain uncertain." Albeit referred to L2 acquisition, these words can perfectly be applied to the study of individuals with two L1s, i.e. simultaneous bilinguals. This research has certainly not developed such precise ways to quantify linguistic input, but, based on different self-reports, it was determined whether the early bilinguals had had extensive or limited input and use opportunities in their heritage language. In dark green appear those classified as native without any doubts whatsoever, in pale green those classified as probably natives, and in white those who did not pass for natives.

Speaker	Use of HL during childhood	Use of HL nowadays
GEB02	Limited	Limited
GEB03	Limited	Limited
GEB04	Extensive	Limited
GEB05	Extensive	Extensive
GEB07	Extensive	Limited
GEB08	Extensive	Limited
GEB09	Extensive	Limited
GEB10	Extensive	Limited
SEB01	Extensive	Extensive
SEB02	Extensive	Extensive
SEB03	Extensive	Extensive
SEB04	Extensive	Extensive
SEB05	Extensive	Extensive
SEB06	Limited	Extensive
SEB07	Limited	Extensive
SEB08	Limited	Extensive

Table 140: Heritage language ratings & heritage language use in child- and adulthood.

Despite the imprecision of this categorical division between extensive and limited heritage language use during childhood, this variable seems to be crucial. As can be seen in table 140, all early bilinguals who attained a native pronunciation in their heritage language reported extensive use of it during childhood, except for speaker GEB03. There are also some speakers who reported extensive use of their heritage language during childhood and nonetheless did not attain a native-like pronunciation. Two logical remarks, which are not mutually exclusive, follow from this datum: 1) a finer quantification of the input and use during childhood is required in order to quantify the critical mass of input required to develop a native-like accent, and 2) age of acquisition and amount of input can seemingly account for much of the variation found in global accent ratings, but there other factors such as linguistic aptitude and attitude must also play a role.

In any case, the results are unequivocal in showing that it is highly unlikely that somebody with limited input/use of a heritage language during childhood may attain a native-like pronunciation even if acquired simultaneously. A particularly illustrative example is speaker GEB02, whose mean score for her heritage Spanish is one of the worsts in the study (only three late bilinguals scored worse in their L2 German). Future studies should attempt to incorporate in their design precise ways to quantify input during childhood.

Furthermore, it is important to note that current use of the heritage language does not seem to be a crucial factor to determine whether the early bilinguals are perceived in that language as natives. Should that be the case, more SEBs would have been rated as natives in German than GEBs in Spanish, since all of them resided in Germany at the time of testing, whilst only one GEB reported extensive current use of Spanish. However, the proportion of speakers taken for natives in their heritage language is almost equal in both groups. It is true, however, that the degree of certainty for this nativeness judgments is higher among SEBs than among GEBs.

In sum, the fact that language use during childhood correlates much better with nativeness in the heritage language than current language use reinforces the idea that some changes do take place in our brain during childhood that affect adult performance. It is unclear, however, whether these changes are maturational (as proposed in the CPH) or whether the result of the bilinguals' linguistic experience (as proposed in the Competing Model). Hernandez, et al. (2005) defend that the "neuronal organization of language" in bilingual speakers reflect their life-histories. Whereas simultaneous balanced bilinguals store their two languages separatel, adult L2 speakers would present relatively little L1-L2 separation, which results in more interferences. They also claim that neurolinguistic studies tend to support this view. These authors, nonetheless, also admit inherent maturational changes, namely the loss of neuronal plasticity. Furthermore, these authors note that the more often one of the languages is used, the more separated the two languages are in the brain; likewise, using that language becomes more automatic. Much is still unknown about the functioning of the brain, but it is well known that when an action is repeated all over again and again to the point of becoming a habit, neuronal connections are built in the brain in order to perform this action automatically. This applies to language learning (e.g. advanced learners do not need to think to build most of their L2 sentences, but absolute beginners do), but also to other actions such as riding or driving.

There seems to be an opportunity window during which the neuronal connections required for language interaction are built very easily; besides, the more use we make of these connections, the more entrenched they become (hence the higher difficulty of avoiding L1 transfer into the L2 and of forgetting our L1 as the speakers move into adulthood).

Speaking a new language requires the creation of new connections in our brain that allow us to perform repetitive tasks unconsciously (e.g. moving the tongue, the lips, or the glottis in specific ways to perform recurrent L2 sounds). It seems plausible to assume that, for the sake of efficiency, our brain will try to make use of the cognitive resources already available to us, i.e. those linguistic resources built up for our L1. From a perspective of economy of cognitive resources, this is logical, since both native and non-native speakers of a language can certainly understand speakers with noticeable accents. In other words, there is little communicative need to make the cognitive effort of getting rid of your accent. Whereas the transfer of L1 grammar and especially of lexicon jeopardises the communication, much L1 phonetic transfer can be accepted by the listener without wreaking havoc in the communication. Besides, lexical retrieval is certainly less automatic than grammar knowledge or pronunciation. Yet, some aspects of lexicon seemed to be especially entrenched in our brain, e.g. numbers. It is easy to observe how even the most proficient late bilinguals usually prefer counting in their own languages.

In sum, the more automatic a linguistic aspect in our L1 was, the more difficulties we will encounter in our L2. However, theoretical frameworks putting the emphasis in linguistic entrenchment cannot ignore that speakers who have spoken their L2 for considerable periods or even most of their lives (e.g. somebody who emigrated to a country at the age of 18) also fail to sound native-like (see anew 2.2.1 for a review and rejection of the alleged counter-evidence), from which follows that some maturational constraint do take place, albeit gradient and in constant interplay with other factors. Four late bilinguals in this sample corroborate this aspect. They have lived in Germany for 8, 9, 11, and 16 years and they reported to work in German and use it in many of their social interactions (one was even married to a German speaker); thus, the amount of input and the time spent using their L2 is apparently enough to have established solid neuronal connections (monolingual children typically achieve that at very early ages). Yet, these speakers clearly do not sound native.

As will be discussed in the remaining part of this section, their L2 phonetic systems are clearly affected by their L1. Many of the interactions between the two phonetic systems can be explained by means of Flege's (2007: 367). Speech Learning Model for L2 acquisition, which predicts that similar sounds are more difficult to acquire than new ones because all speakers have a perceptual filter that is language-dependant (there is an important precursor to his model, namely Trubetzkoy's "phonological sieve"; 1939: 47-50). However, the theory here defended goes beyond that theoretical framework by incorporating other aspects into the model, such as the natural seek of cognitive resources efficiency by part of the bilinguals and the functionality possibilities of the different forms of L1 transfer within the L2 phonetic system. This framework aims to deal with the fact that many advanced learners do perceive some L2 phonetic characteristics, apply them even with great consistency, and, yet, present some phonetic differences. The necessary framework to deal with this fact is built upon the following rationale:

1) Speaking an L2 requires to modify many of our muscular habits (with their correspondent brain activity attached that allow us to do it without automatically).
2) Apart from modifying these muscular habits, other cognitively demanding tasks with greater communicative reward are also required, such as L2 lexical retrieval and the application of grammatical rules.
3) Evidence on L2 acquisition allows us to conclude that the brain tends to reutilise already available devices in order to simplify this cognitively demanding task. Many L2 mistakes are typically explained in terms of L1 interference.
4) As learners progress, the brain must face two tasks: I) accessing L2 knowledge and II) blocking access to L1.
5) Blocking access to L1 will be more difficult for those tasks that are most repetitive, since they are more entrenched in the brain. Thus, getting rid of the muscular habit of, e.g., pronouncing /p/ without aspiration will be more cognitively demanding for an L1 Spanish speaker than, e.g., not saying *perro* instead of *Hund* 'dog', because the frequency of the phoneme /p/ is immense compared to that of the word *perro*.
6) Apart from the cognitive difficulty of blocking the L1, there are functional aspects to bear in mind. Whereas the use of L1 words and L1 grammar rules clearly jeopardises communication in the L2, pronouncing L2 phonemes with heavy L1 influence does not hinder communication providing a minimum of the L2 phonetics has been acquired.
7) There are also different degrees in functionality within one linguistic domain. It is, e.g., more functional to keep the contrast between a tense and a lax vowel both in terms of formant structure and length (as monolinguals do) than just in either formant structure or length. But L2 communication can be perfectly functional without acquiring all L2 characteristics.
8) The perceptual filter proposed by the SLM can predict which phonetic aspects will be more successfully acquired based on their phonological relevance in the L1 (and to some extent on individual perceptual abilities), whereas the fact that some features are perceived and yet not phonetically identical to those of monolinguals can be explained if we include functionality and cognitive efficiency. If blocking L1 access is cognitively demanding, it is logical to assume that the brain will only do it as long as it is communicatively necessary. Once a modified L1 sound has been modified enough to be perceived as a token of an L2 phoneme (albeit deviant), it is already functional and there is no communicative need that justifies the demanding task of blocking L1 interference.

9) After considering L1 perceptual filters and functionality in the L2, there are still individual differences that can probably be explained in terms of: a) phonetic aptitude (including both perception and the muscular ability to mimic sounds) and b) desire to sound native-like.

In what follows, this framework will be applied to the acoustic data reported in 3.4. As predicted by Flege's Model, the SLBs had many problems in differentiating the German pairs of tense vs lax vowels /eː/ vs /ɛ/, /øː/ vs /œ/, /ɪ/ vs /iː/, /yː/ vs /ʏ/, /oː/ vs /ɔ/, and /uː/ vs /ʊ/. All existing differences in formant structure have indeed virtually disappeared in the speech of SLBs and the contrast has been reduced to one of vowel length. Long vowels do not exist in Spanish and the space occupied by the Spanish vowels embraces for the most part both the corresponding tense and lax vowel (see again 2.1.5); in other words, as predicted, the most dissimilar characteristic of these opposing pairs has been acquired.

From a purely functional point of view, there are well-founded reasons to believe that differences in vowel length in the late bilinguals are enough to keep the phonemic contrast between the tense and lax vowels. For instance, German /aː/ and /a/ do not need to differ in formant structure to keep the phonemic contrast, neither do Estonian vowels (Asu & Teras, 2009).

Besides, the Speech Learning Model alone does not suffice to explain why tense vowels are 61% and 51% longer than lax ones in our sample for monolinguals and late bilinguals, respectively). This fact leads us to an important question: if Spanish L1 late bilinguals do perceive differences in vowel length, why do they not lengthen their tense vowels as much as monolinguals do? Furthermore, why do two late bilinguals produce vowels that are as long as those produced by the German monolinguals, whereas the rest produce vowels clearly longer than in Spanish, and yet not monolingual-like?

This framework theorises that producing an increase of 61% in vowel length for tense vowels is more difficult for Spanish speakers than increasing length in only 51%, because there is greater departure from Spanish short vowels, and since an increase of 51% is large enough to be perceived, there is no communicative need to keep on increasing the vowel, which goes against the muscular habits of the speaker, and some cognitive resources necessary to modify such an entrenched habit remain to a greater extent might be thus free to be used with more communicative efficiency in other linguistic domains. Lastly, it must be noted that two late bilinguals do produce vowel length values comparable to those of monolinguals, which leads us to the scenario explained in point 9. Whether the individual differences of these two speakers obey to a better phonetic aptitude or attitude can unfortunately not be answered with this research.

A further important difference between German and Spanish vowels is lip-rounding as a distinctive feature between vowels produced with the exact same tongue position, e.g. /iː/ and /yː/. SLB's data on lip-rounding are very different to those for the phonetic correlates between tense and lax vowels. As a group, SLBs show fewer F3 decreases than monolinguals. However, if we exclude the two late bilinguals with no F3 decrease, the F3 decreases of SLBs and GMNs are almost identical. Thus, it seems that there are two speakers who did not implement any contrast whatsoever based on lip-rounding, whereas the rest not only acquired that phonological feature, but also produce phonetic tokens identical to those of the monolinguals. Contrary to vowel length, which allows more intermediate values, lip-rounding is (almost) categorical, either a vowel is rounded or unrounded. The changes in the acoustic signal are smaller compared to those in vowel length contrasts, and thus, it is less functional to adopt intermediate values. Among monolinguals, mean F3 decrease in rounded vowels is only 6% compared to their unrounded counterparts, and no monolingual present decreases lower than 4%, which seemingly suggests that smaller changes may not be perceived; hence the dichotomy found in the late bilinguals, either the feature is acquired or not, but if acquired it matches perfectly the L2 target.

Cross-linguistic evidence seemingly confirms that the human ear perceives lip-rounding categorically (although, from an articulatory point of view, there may be different degrees of lip-rounding). Most languages in the world that contrast two phonemes by means of lip-rounding have two categories, but a bunch of languages have been claimed to have a three-way contrast, to my knowledge: Swedish (Engstrand, 1999) and Ningbo Chinese (Hu, 2006). These three languages are claimed to contrast between unrounded vowels, rounded vowels with protrusion, and rounded vowels with compressed lips (in Engstrand, 1999, the terms outrounded and inrounded are used to describe protruded and compressed vowels, respectively). In other words, these three languages do not make use of intermediate values of lip-rounding, but of two different types of lip-rounding. Furthermore, Ladefoged & Maddieson (1996: 293-295) analyse the evidence for such claim in Swedish and notes that /i/, /yː/, and /ʉ/ “have similar (although not identical) tongue positions”. In their review of the world’s vowels, they also cite one language in the world that might contrast between different degrees of the same type of lip-rounding: Assamese (a language from north-western India). Nonetheless, they are somehow sceptical about it, since they also mention that the vowels that would present such contrast also differ in tongue-position. In sum, the cross-linguistic evidence confirms that, because of perceptual constraints, it is not functional to adopt intermediate values for lip-rounding.

Lastly, there is another interesting aspect worth discussing regarding vowels. The sound [ɐ] is acoustically very similar to [a]; interestingly, the distances between these two sounds are greater in both the SEB and SLBs groups than among GMNs and GEBs, which can be interpreted as a case of phoneme dissimilation within the Speech Learning Model, i.e. the speakers maximise the contrast in order to keep separate categories with an existing phoneme in their L1.

Unlike Flege’s Speech Learning Model, this theoretical framework can also be applied in the analysis of simultaneous early bilinguals. This kind of speakers do not have an L2 in a chronological sense like the late bilinguals, but they do have a language which is more dominant in terms of input and use, which is, unless in exceptional cases, the societal language. Although no perception test with simultaneous bilinguals in their heritage language is known to me, it seems quite plausible to assume that any differences in the phonetic outcome of these speakers cannot be attributed to perception differences, since they have acquired both languages since birth at home. However, speakers with limited input and, probably more importantly, without active use of a language may have no cognitive need to establish neuronal connections as robust as those they established for their societal language.

The acoustic analyses revealed that the early bilinguals behaved like monolinguals at group level in both their societal and heritage languages for vowels. Perhaps the only relevant difference is in duration between German tense and lax vowels, which is indeed higher in both groups of early bilinguals. If we apply Flege's Speech Learning Model to this situation, it can be interpreted anew as a case of phoneme dissimilation. In turn, differences in duration between GEBs and SMNs are minimal (except for /a/) and not always in the expected direction. At the individual level, it is worth noting that differences across speakers of the same group are minimal in comparison to those in global scores.

Flege's Speech Learning Model cannot be straightforwardly applied to the study of stops in these Spanish-German late bilinguals. Both languages have three pairs of homorganic stops that also share the same place of articulation in both languages; three stops are fortis, whereas the other lenis. There is, however, an important difference: whereas Spanish stops differ in voicing, German ones differ in aspiration, and the presence of voicing for /b d ɡ/ is only a redundant possibility that relatively few speakers make use of. The German input SLBs receive is as follows: voicing is constant and regular in word-internal /b d ɡ/ tokens (2.1.2.1.3), subject to much variation in word-initial intervocalic /b d ɡ/ tokens (2.1.2.1.2), and relatively infrequent in absolute initial position (2.1.2.1.1). This scenario is especially complex from a Spanish-speaking perspective, in which voicing is a distinctive feature, whereas for German speakers the complexity is irrelevant, what is most crucial is the presence or absence of aspiration.

De Villa's (1792: 23-24) *Gramática de la lengua alemana dividida en tres partes* confirms that at least some phonetically naive speakers can detect the differences in voicing for Spanish and German /b d ɡ/ in absolute initial position (and yet some monolinguals do voice these phonemes), but future research is necessary to determine if there is a relation between German voicing perception and production among SLBs for /b d ɡ/. Beyond perception, it must be noted too, that, in terms of cognitive efficiency, the effort of not voicing German /b d ɡ/ is quite useless, since for the German phonological system it is only relevant whether there is aspiration or not. German monolinguals, however, albeit unconsciously, do perceive voicing, since there is a clear prevalence of [b̥ d̥ ɡ̊] over [b d ɡ], but a higher sociophonetic value does not seem a very appealing reward to SLBs so that avoiding voicing in /b d ɡ/ is worth the effort. Indeed, only two SLBs produced voiceless tokens for German /b d ɡ/ with relative consistency. Interestingly, this aspect is one of the few in which GEBs and GMNs clearly differentiate from each other. Voicing for German /b d ɡ/, albeit not canonical, is clearly more present in the group of early bilinguals than among the monolinguals. Likewise, SEBs, who patterned like monolinguals very closely for vowels, also clearly differ from GMNs in this aspect in also presenting more voiced tokens. However, the impact of the societal language is also clear, and voicing is more recurrent among SEBs than among GEBs.

Incorporating the impact of the linguistic transfer into each phonetic system also allows to explain why transfer does not take place with the same intensity from Spanish into German than the other way around. As noted, voicing is phonologically relevant in Spanish; thus, not surprisingly, all bilingual groups produce non-canonical /b d ɡ/ forms considerably less often in Spanish than in German.

Regarding /p t k/ in both languages, the situation for the SLBs resembles much of that vowel length, i.e. these speakers are generally aware of the phonological importance of aspiration in German and, consequently, aspirate their /p t k/ tokens, but without reaching the aspiration values that are typical of German. Whilst only two SLBs presented lower percentages of voiced /b d ɡ/, only two SLBs have very low aspiration values. As noted for vowels, perceiving that a feature is phonologically relevant does not lead to phonetically indistinguishable production. Taken all fortis tokens together, VOT was over 40 ms for most SLBs, which is clearly lower than typical for German, but most likely also perfectly functional to contrast with monolinguals' [b̥ d̥ ɡ̊], who typically have a VOT of 20 ms or even lower. Anew, these speakers are willing to carry out the cognitively demanding task of changing their muscular habits to produce sounds that are similar in their L1 only when it is phonologically distinctive; besides, if the phonetic correlate allows intermediate values, the changes will be carried out as long as it is perceptually necessary.

In turn, there is a slight asymmetry between the production of the SEBs and the GEBs. The former produced monolingual-like fortis stops in Spanish, but considerably less aspirated than typical for German, whereas the latter produced monolingual-like Spanish fortis stops and typically aspirated /p t k/ tokens in German. A possible explanation is that whereas in the societal language of GEBs there are voiceless non-aspirated stops [b̥ d̥ ɡ̊], which are very similar to Spanish [p t k], in the societal language of the SEBs there is no aspirated stops. Thus, the cognitive effort might be bigger for the SEBs than for the GEBs. Lastly, it is also worth noting that in other studies with early bilinguals (Gabriel et al., 2018) VOT differences with monolinguals were also found in the societal language.

As for unstressed intervocalic stops, the late bilinguals produce Spanish fortis stops virtually indistinguishable from monolinguals' but less aspirated than usual in German; in turn, /b d ɡ/ are lenited to approximants with the same frequency with which monolinguals do it. The situation for fortis stops mirrors, thus, that of absolute initial position: as predicted by the Speech Learning Model, aspiration is acquired, but because there is no communicative need to aspirate to the same extent that monolinguals do, these late bilinguals produced shorter aspirated stops. On the contrary, given that, to some extent, voiced stops and their approximant counterparts are acoustically similar (all except for one GMN use both in unstressed position), it is relatively strange that the late bilinguals did not produce more phonological stops in their approximant phonetic form. A further reason to expect such outcome is that the lenition into approximant in Spanish is compulsory intervocalically, whilst in German it is optional when in unstressed position. A possible explanation is that, according to the literature, lenited stops are very rare in stressed position for German, and the late bilinguals may have simply applied this phonetic knowledge also to unstressed position.

The performance of both SEBs and GEBs also offers interesting aspects. Whereas SEBs produced the same proportion of approximant tokens than GMNs and SLBs, the GEBs are clearly more canonical than the monolinguals; the presence of approximant tokens among monolinguals doubles that among GEBs. It must be remembered that the lenition is redundant in perceptual terms for German, since what is important is the absence of aspiration and the contrast in tenseness. Therefore, the presence of lenition in intervocalic /b d ɡ/ German stops is to some extent analogous to that of voicing in absolute initial stops. However, whereas some GEBs used voicing more often than German monolinguals, GEBs use more canonical intervocalic /b d ɡ/ stops than monolinguals. A possible explanation is that the GEBs may associate the presence of intervocalic lenited stops to a strong mark of Spanish influence (in stressed position it would certainly be the case). Furthermore, although specific studies investigating the sociophonetics of German should confirm the following hypothesis, the presence of voicing in absolute initial position may be a sign of clearer or more formal speech (the vibration must be actively sought), whereas the lenitions are typically associated with casual and less educated speech.

It is well known that some simultaneous bilinguals temporarily refuse to reply to their parents in their heritage language (Baker, [2]2000), and in so doing their desire not to outstand linguistically becomes patent. Thus, bilinguals might be unconsciously avoiding phonetic forms that have little prestige in order to fit perfectly in the linguistic community of their societal language. Nonetheless, the presence of voicing in absolute initial position would not be as prone to be avoided since it is easier to apply the same feature in both languages and there is no sociophonetic penalty. To my knowledge, it has not been much investigated whether early or simultaneous bilinguals tend to favour more canonical forms than monolinguals, but Konopka & Pierrehumbert (2008) noted that their early bilinguals did not fully participated in the vowel changes taking place in and around Chicago.

On the contrary, all bilingual groups implemented the phonological rule whereby Spanish stops become lenited in intervocalic position as consistently as the monolinguals. As noted in 2.1.2.2.2, it is not unfrequent to find partially or fully voiced /p t k/ tokens, which nonetheless does not jeopardise the contrast with their lenis counterparts because the latter are always pronounced as approximants in this position. Because of the perceptual importance of leniting /b d ɡ/ into approximants, it is thus not surprising that no exception was found among bilinguals.

Among German fricatives, there are some completely new sounds for L1 Spanish speakers, /v/, /z/, /ʃ/ and /ʒ/. /ʃ/ was acquired without any hint of foreign accent by part of the late bilinguals, whereas some speakers did not fully voice /v/, /z/, and /ʒ/. Interestingly, there seemed to be a physiological difficulty for the SLBs in fully voicing these sounds the more the place of articulation moves backwards. Even more problematic is the tri-allophonic distinction for the phoneme /x/, which presents three possible realisations depending on vowel context: [ç], [x], and [χ] (Kohler, [2]1995: 160-161; reviewed in 2.1.3.2.8). The palatal fricative /ç/ is the most different sound to Spanish /x/ for all the late bilinguals and was, as predicted in the Speech Learning Model, well acquired. However, most late bilinguals made no distinction between velar and uvular realisations. Lastly, no traces of L2 transfer in Spanish fricatives can be observed.

Similarly, those SEBs who speak a variety wherein in [ç] is absent have successfully created that sound category but have failed to further differentiate between velar and uvular realisations [x] and [χ]. It must be noted, however, that the distinction between [x] and [χ] is not very functional, since it has no phonological character; besides, not even all German monolinguals keep it. In sum, the effort of creating three allophones for /x/ is not communicatively worth it. On the contrary, the acoustic distances between [x] and [χ] are more robust among GEBs than among GMNs, which might be interpreted as another signal of a tendency to produce more canonical tokens.

Regarding voicing, also SEBs and GEBs show some differences with the GMNs; however, the differences for the GEBs are quite small except for /ʒ/. Besides, the trend found among SLBs whereby voicing seemed to be easier to produce for /v/ than /z/ and for /z/ than for /ʒ/ was also observed among SEBs, thus confirming that there is a physiological reason.

Lastly, the production of rhotics, unlike other sound classes, presents vast inter-speaker differences within the group of late bilinguals. Whereas only two speakers consistently produced uvular tokens (which are also phonetically indistinguishable from monolinguals'), some late bilinguals transfer consistently or with high recurrence the rhotics system from Spanish into German, which is surprising given their proficiency in the rest of the linguistic domains. This clearly goes against the Speech Learning Model, since German and Spanish rhotics are very different. However, if we move the focus to functionality, it is not surprising to find those phonetic behaviours, since this total transfer of the Spanish rhotic system does not jeopardise communication at all. Neither alveolar trills nor taps exist in the German variety spoken by these bilinguals and, thus, there is no potential communicative problem. Besides, it must be noted again that the SLBs found the simultaneous production of friction and voicing problematic, especially as the place of articulation moves backwards (German rhotics are voiced uvular fricatives in their German target-variety).

Another striking finding about rhotics is that whereas no GEB speaker pronounced Spanish rhotics in a German fashion, several SEBs produced German rhotics in the alveolar region, i.e. with transfer from Spanish. This is much remarkable, since for the other sound classes neither departed drastically from monolinguals in any of their two languages. The most likely explanation relies on the phonological differences between German and Spanish rhotics. In German there is one single rhotic phoneme, whereas there are two in Spanish; thus, GEBs cannot simply transfer the pronunciation of /ʁ/ into all Spanish rhotics because of the phonological opposition between /ɾ/ vs /r/. In other words, there is a powerful communicative need to acquire both sounds. The opposite, however, is not true, since there is no communicational problem for a Spanish dominant bilingual to transfer both sounds into German with the same distribution they have in Spanish. They are definitely perceived as deviant realisations in northern Germany but cannot be confounded with any other phoneme and are perfectly functional. The fact that these Spanish dominant bilinguals transferred the two sounds with the same distribution they have in Spanish can be checked by noting that alveolar trills were only produced for the German word for Austria, i.e. *Österreich* (the spelling <rr> always represent an alveolar trill in Spanish).

Lastly, it is worth noting that the GEBs not only consistently avoided transfer from German into Spanish, but also produced more canonical taps, i.e. with an actual occlusion instead of approximant-type taps, than the rest of the groups. Likewise, whereas the mean number of lingual contacts per trill is lower than one in four SEBs, no GEB presented a mean lower than one.

The final aim of this discussion is comparing the perceived differences between bilinguals and monolinguals (global accent ratings) with the existing differences between them (acoustic analyses). In this regard, the following important aspects must be highlighted:

1) Both acoustic and global accent differences between GMNs and GEBs are petty and minimal at group level and inexistent for many speakers. Acoustic differences between SEBs and SMNs, albeit small, are of higher magnitude. These differences between SEBs and GEBs can be attributed to the wider range of Spanish varieties included in the study and by the fact that the SEBs were residing in Germany.
2) Both global accent ratings and acoustic data in the heritage language of both groups of early bilinguals contrast with those of their societal language in presenting a much wider range of inter-speaker variation. Whereas roughly half of the speakers pass for natives in their heritage language, the other half are perceived as foreigners. Most of them even had scores typical for late bilinguals.

3) Those speakers who passed for natives in both languages had better scores in their societal languages, except for one SEB, who scored slightly better in German, and another SEB from Spain, who can be considered ambilingual.
4) The differences in global accent ratings between SLBs and GMNs are enormous. Acoustically, however, the differences in rhotics (except for some speakers), stops, and fricatives are relatively small. At segmental level, their Achilles' heel is clearly their impossibility to contrast tense and lax vowels in both duration and formant structure.

From the correlations between the different acoustic parameters and the global accent ratings (3.4.5) and the regression analyses it can be concluded that segmental differences are a very poor predictor for differences between simultaneous bilinguals and monolinguals, but considerably more useful to predict differences between late bilinguals in their L2 and monolinguals. An illustrative example of the different effects of the same acoustic parameter on global accent is that VOT correlated with global accent in Flege & Eefting (1987) but not in Lein et al. (2016).

In this study, there was a significant correlation between duration and global accent ratings for Spanish, but, according to the regression analyses, it had limited predictive power and the standard error of the estimate was immense. One could expect monolinguals to speak faster than bilinguals, especially GEBs. But it is also important to bear in mind again (see 2.1.1.2.4) that Spaniards speak faster than monolinguals from American varieties (Santiago & Mairano, 2017; Morrison & Escudero, 2007; and Schwab, 2015). Thus, it is impossible to conclude that these participants speak slower because of being bilingual.

On the contrary, there are many correlations between global accents and the different acoustic parameters measured for German (3.4.5), both including and excluding late bilinguals. However, it must be noted that the predictive power of these correlations is very low when excluding the late bilinguals and that there are wide standard errors of the estimate in both cases. This scenario contrasts markedly with that of Spanish in that many more correlations were found; however, the predictive power for global accent of the differences in segmental phonetics is very low for both languages when excluding the late bilinguals (for the sake of comparability), which, in turn, leads us to the question of what causes noticeable differences between monolinguals and early bilinguals in their heritage language at group level. There are different candidates and probably all of them exert some influence on global accents, namely speech rhythm, speech rate, and intonation.

Speech Rhythm is most likely not a good predictor of global accent. This interaction was not studied in Coetzee et al. (2015) and Henriksen (2016), but the former work concluded that L1 Afrikaans Speakers in Patagonia (Argentina) largely patterned with monolingual speakers. Similarly, the highly proficient L1 Spanish – L2 English speakers in Henriksen (2016) also patterned with English-speaking monolinguals. Lastls, Polyanskaya et al. (2016) found that it made a larger contribution to perceived foreign accent than speech rate.

Speech rate can possibly account for a (small) part in global accent differences. Lexical retrieval is most likely more cognitively demanding for late bilinguals and early bilinguals with limited use opportunities of their heritage language, to which some grammatical uncertainties can be added; as a result, it seems plausible to assume that monolinguals will generally speak faster. Needless to say, individual and even dialect differences are large in this regard. In Major (2007), it was noted that raters without any knowledge of the rated language performed with surprising accuracy. Probably, speech rate is one of those clues that they made use of.

Finally, intonation is probably the best candidate to account for more differences in global accent when using highly proficient speakers. Gut (2007) noted that less marked intonational patterns are probably a universal characteristic of L2 pronunciation (which could be also perceived by the above-mentioned raters in Major, 2007). Ulbrich & Mennen (2016) after revising different studies signal that, so far, the evidence is not conclusive as for intonation has a deeper impact on global accent ratings than segmental phonetics. In their own study, segmental differences were more important than intonation. As noted before, the answer to this question is most likely heavily dependent on the type of bilinguals investigated. In the regression analyses here reported for German, it became patent that the influence of segmental phonetics was much more important when the late bilinguals were included, which resembles the findings in Ulbrich & Mennen (2016) with late bilinguals. However, when only the early bilinguals are included it was also clear that segmental phonetics could for little variation in global accents. Thus, there seems to be a pattern whereby the higher the proficiency of a speaker, the higher the impact of intonation on global accent ratings, whereas speakers with lower proficiency are perceived as non-native because of both their differences in intonation and segmental phonetics. These ideas were expressed in similar terms in Polyanskaya et al. (2016); these authors suggested that "the segmental characteristics override deviations in temporality from the target patterns in L2 speech. The importance of fine-tuning rhythmic and tempo patterns grows as proficiency increases, segmental deviations diminish, and more attention is diverted towards temporality during the perception of L2 speech".

It is also important to note the precocity observed for intonation acquisition in comparison with other linguistic aspects. Frota & Butler's review (2018: 145-153) shows that children younger than 12 months already perceive some differences in intonation. If the acquisition of intonation begins at a very early stage, even before that of segmental elements (it has even been claimed that new-born's cry melody is affected by their L1; Mampe et al., 2009), it is plausible to assume that intonational patterns are more robustly entrenched in our brain than any other linguistic aspects. Furthermore, the communicative reward for learners of non-tonal languages, like Spanish and German, is far greater for segmental aspects than for suprasegmental ones. Thus, a higher cognitive difficulty is combined with a low communicative reward.

4. Conclusion

The main goal of this research was to investigate whether there are phonetic differences at the segmental level between bilinguals and monolinguals and to determine the extent to which those differences have an impact on global accent. A secondary goal was to identify which variables in the speakers' linguistic biographies best predict their phonetic outcome.

Whereas global accent ratings are useful to determine which bilinguals are *perceived* as natives, acoustic studies allow us to determine whether they *are* different. Those perceived as non-native speakers in terms of pronunciation will inexorably present phonetic differences, but those perceived as natives may present some differences that are simply not perceptually salient. Indeed, it is likely to be the case; in monolingual communities there is also a great deal of phonetic variation which the speakers are often not aware of. Furthermore, the combination of acoustic and global accent studies allows to study on which phonetic basis they are perceived the way they are.

Much linked to the question of whether bilinguals and monolinguals differ in pronunciation is the question of how the two bilingual phonetic systems interact. Sometimes this interaction takes place in the form of a total or partial transfer (e.g. some bilinguals use alveolar trills and taps instead of German [ʁ]), whereas in some occasions it is much more subtle and takes the form of a merger (e.g. some bilinguals have modified their VOT values in both languages), which does not necessarily take place at midpoint between the two phonetic systems.

The analyses had to be limited to 24 bilinguals because of the time-consuming task of acoustically analysing these 24 speakers in their two languages plus 16 monolinguals. Such detailed acoustic analyses were essential to address the main research goal, but this limitation of participants had the side effect that, given all variables that come into play in bilingual language acquisition, it was impossible to cover with statistical robustness all the possible combinations between all the variables that have been reported in the literature to have some effect.

Addressing the main research question, it must be noted that the acoustic analyses have revealed that the three groups of bilinguals present differences with the monolinguals in both languages; however, there are generally large differences between their two languages. This is particularly true for the late bilinguals, who had minor signs of L2 interferences in their L1 Spanish (e.g. some speakers produced greater VOT values than those typically found in Spanish), but whose L2 phonetic system presented important deviations from monolingual norm: the tri-allophonic distinction of /x/ was generally simplified into two allophones, voiced fricatives were not as voiced as among monolinguals, the contrast between tense and lax vowels in terms of formant structure was lost, whereas the duration contrast reduced, Spanish rhotics were sometimes transferred, the VOT values for /p t k/ was shorter than the typical ones, and voicing was usually transferred for /b d g/ in absolute initial position. Some of the differences between late bilinguals and monolinguals can be explained in terms of differences in perception (Flege, 2007: 367; Trubetzkoy, 1939: 47-50), but, as discussed in 3.5, the late bilinguals also present differences in some phonetic aspects that they do perceived. These phonetic deviances were, however, fully functional, since they allowed the discrimination between phonemes. For instance, tense vowels and aspirated stops were shorter than typical and, yet, different enough from lax and unaspirated stops. It was also noted that transfer in those aspects that did not jeopardise the communication (e.g. transferring Spanish rhotics into Spanish or voicing in absolute initial stops) were more frequent than those aspects that went against key aspects of the German phonological system. Thus, the transfers between the two languages of the early bilinguals are not only perceptually triggered, but also respond to the search of a balance between functionality in the L2 and the minimum possible departure from the L1.

In turn, the early bilinguals presented minute differences with the respective monolinguals in their societal language. In this regard, the case of the GEBs, who were completely homogeneous to the German monolinguals in terms of variety spoken, is particularly interesting. In this group, a slight tendency for more canonical forms was found except for the higher presence of voicing in absolute initial position for /b d g/. It is not surprising that the only transfer that some speakers carry out from their heritage language into their societal language is precisely in this phonetic aspect that, as the monolingual data prove, shows some variation among monolinguals. Besides, the deviation from the canonical form in this aspect may even have a positive sociophonetic value attached (it could be a sign of careful speech, since the perceptual contrast is maximised).

Conversely, the early bilinguals presented more differences in their heritage languages with the respective monolinguals. These differences reflected their language dominance. For instance, some SEBs transferred Spanish rhotics into German, whereas some GEBs produced voiceless tokens for /b d g/.

These segmental differences, however, had little predictive power for global accent ratings, as the differences in global accent ratings were much larger than those of the acoustic studies. All early bilinguals without exception passed for natives in their societal language. The testing of the SEBs had the limitation of having taken place in Germany and the fact that this group (and the raters) were heterogeneous in terms of Spanish variety spoken. Consequently, some differences between SEBs and SMNs were found. However, GEBs were indistinguishable from German monolinguals. Furthermore, only around half of the early bilinguals also passed for natives in their heritage language; although their ratings were generally lower in their heritage language (raters usually classified them as natives but admitted doubts in their judgements). All early bilinguals who passed for natives in both languages reported extensive use of their heritage language during childhood. This goes in line with the Competing Model, which predicts that if the two languages are spoken during childhood (when our brain has more neuronal plasticity), the two languages will be stored separately and "competition" between the two languages will be minimal. Lastly, only the performance of one late bilingual presented signs of heavy language attrition, as she was perceived as a non-native speaker in her L1 Spanish. Conversely, no late bilingual passed for native in German or was close to it, which goes in line with both the CPH and the Competing Model.

From the regression analyses results, it can be concluded that segmental phonetics can serve as a very powerful predictor of global accent differences for the late bilinguals in the L2, but among early bilinguals little of the variation in global accent could be explained by means of phonetic differences at the segmental level. In all likelihood, intonation is responsible for the large differences in the heritage language global accent ratings.

Finally, the secondary research question will be addressed. Because of the time-consuming task of acoustically analysing the data produced by the participants, the number of variables that can predict the above-mentioned acoustic and global accent differences had to be reduced. Namely, only the following variables were considered in the analysis: age of acquisition, language use, and cultural affiliation. Age of acquisition was considered only categorically; the speakers were either late bilinguals or simultaneous bilinguals (except for four very early bilinguals). Language use was considered both during childhood and currently and, anew, a categorical approach was followed, as it was only distinguished between extensive and limited use. Lastly, cultural affiliation was measured with a 1-6 Likert scale. This set of variables, despite its limitations, covers the two variables that have been said to affect the most linguistic outcomes. However, future research needs to incorporate more accurate ways to measure linguistic input/use as well as linguistic aptitude tests.
The results show that age of acquisition and amount of input during childhood can account for much of the variation found among these speakers. The results obtained from the analyses performed on the late bilinguals' data go in line with the studies reviewed in 2.2.1, as no L2 speaker had a native-like pronunciation. Similarly, the results of the early bilinguals confirm that early acquisition is no guarantee of native-like performance (Abrahamsson & Hyltenstam, 2009), as only half of the speakers passed for natives in their heritage language. In this regard, the amount of input during childhood proved to be crucial, as only those with extensive use of the heritage language passed for natives in that language. Furthermore, even agreeing with Flege (2007: 376) in that precise tools to quantify language input and use must be developed, based on the findings with these speakers and, especially, on the existing literature, it can be safely concluded that the combined effect of age of acquisition and amount of input

cannot account for all the differences among bilinguals. Individual differences such as linguistic attitude and, especially, linguistic aptitude most likely play a role.

In sum, the model of bilingual acquisition defended in this dissertation recognises age of acquisition as the most crucial aspect, but also includes other important variables. Thus, the evidence suggesting maturational constraints, as proposed in CPH (2.2.1.1), and the Competing Model (Hernandez et al., 2005) have been brought together and complemented with the contributions on language aptitude (Bylund et al., 2009) and type and amount of input (Flege, 1987). Finally, Flege’s Speech Learning Model was taken as the starting model to interpret the acoustic differences in the speech of the late bilinguals. However, this model fell short to explain why late bilinguals depart from monolinguals also in the aspects that they do perceive. Furthermore, the perceptual filter proposed by Flege said nothing about the differences in the early bilinguals. In order to interpret the results of the acoustic analyses, it was thus theorised that both early and late bilinguals consider the impact of the transfer from the L1 into the L2 (late bilinguals) and from their societal into their heritage language (early bilinguals). Thus, those aspects that do not have phonological consequences in the target language are more easily transferred. Likewise, when the late bilinguals need to acquire an L2 phonetic characteristic, they normally depart as little as possible from the corresponding L1 sound, but as much as necessary so that their tokens are perfectly functional in their L2.

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Appendix

Bilingual speakers' sociolinguistic information:

Code*	USP_N	USP_CH	UGE_N	UGE_CH	G	I	LORG	SP. VAR.
GEB02	Limited	Limited	Extensive	Societal	Female	4		Chilean
GEB03	Limited	Limited	Extensive	Societal	Female	4		Colombian
GEB04	Limited	Extensive	Extensive	Societal	Female	3		Chilean
GEB05	Extensive	Extensive	Extensive	Societal	Female	5		Peruvian
GEB07	Limited	Extensive	Extensive	Societal	Female	2		Argentinean
GEB08	Limited	Extensive	Extensive	Societal	Female	4		Peruvian
GEB09	Limited	Extensive	Extensive	Societal	Female	4		Chilean
GEB10	Limited	Extensive	Extensive	Societal	Female	4		Central Sp.
SEB01	Extensive	Societal	Extensive	Extensive	Female	4	7	Panamanian
SEB02	Limited	Societal	Extensive	Extensive	Female	4	15	Mexican
SEB03	Extensive	Societal	Extensive	Extensive	Female	4	46	Bolivian
SEB04	Limited	Societal	Extensive	Extensive	Female	3	0.5	Canarian
SEB05	Limited	Societal	Extensive	Extensive	Female	3	2	Chilean
SEB06	Extensive	Societal	Extensive	Limited	Female	3	1	Argentinean
SEB07	Limited	Societal	Extensive	Limited	Female	2	1	Argentinean
SEB08	Extensive	Societal	Extensive	Limited	Female	4	24	Chilean
SLB01	Limited	Societal	Extensive	None	Female	2	8	North. Sp
SLB04	Limited	Societal	Extensive	None	Female	2	2	Argentinean
SLB05	Limited	Societal	Extensive	None	Female	2	16	Central Sp.
SLB06	Limited	Societal	Extensive	None	Female	2	4	Central Sp.
SLB09	Limited	Societal	Extensive	None	Female	3	2	Central Sp.
SLB13	Limited	Societal	Extensive	None	Female	4	9	Central Sp.
SLB16	Limited	Societal	Extensive	None	Female	4	11	North. Sp
SLB18	Limited	Societal	Extensive	None	Female	4	3	Colombian

Table 1 legend:
USP_N: use of Spanish nowadays
USP_CH: use of Spanish during childhood
UGE_N: use of German nowadays
UGE_CH: use of German during childhood
G: gender.
I: identity (1 Respective Spanish-speaking country – 6 Germany)
LORG: length of residence in Germany (in years).
SP_VAR.: Spanish variety of reference
* Code: societal language and linguistic group can be

Spanish sentences set

1. Entrevistador: ¿Quién es?
   Participante: El señor Pérez.
2. Di los días de la semana.
   Lunes, martes, miércoles, jueves, viernes, sábado y domingo.
3. Entrevistador: ¿Qué hace la chica de la foto?
   Participante: Bebe una limonada.
4. Entrevistador: ¿Cómo se va a llamar la peque?
   Participante: Se va a llamar Dafne, como la ninfa.
5. Entrevistador: ¿Y esas mochilas?
   Participante: Nos vamos de excursión, ¿te vienes?
6. Entrevistador: ¿Qué dice Ana?
   Participante: Que se bebió una limonada.
7. Entrevistador: Sí, sí, en seguido lo hago.
   Participante: Hazlo ya, ¡por favor! ¡Que se va a hacer tarde!
8. Entrevistador: ¿¿Pero qué te ha pasado??
   Participante: Nada. Es solo una pequeña infección.
9. Entrevistador: ¿Qué hace María?
   Participante: María come mandarinas.
10. Entrevistador: ¿Qué hace la niña morena?
    Participante: La niña morena come mandarinas.
11. Entrevistador: ¿De qué planeta vienen los extraterrestres de la película de Spielberg?
    Participante: Del planeta Orótomo.
12. Entras en una panadería y notas un olor a pan muy bueno. Díselo a la panadera.
    ¡Qué olor a pan tan bueno!
13. No sabes si hoy hace frío o no. Entra alguien bien abrigado y le preguntas si tiene frío.
    ¿Tienes frío?
14. En un brindis:
    Participante: ¡Salud!
15. Entrevistador: ¿Cómo se llama la ciudad dónde os vais de vacaciones?
    Participante: Oromaluco.
16. Pide permiso para entrar en la sala donde te espera el médico.
    ¿Puedo pasar?
17. Entrevistador: ¿Cuándo vuelves?
    Participante: En septiembre.
18. Entrevistador: Yo soy de Lima
    Participante: ¿Ah, sí? pues yo viví muchos años allí, en Lima.
19. Entrevistador: ¿Dónde te duele?
    Participante: Aquí, en el abdomen.
20. Entrevistador: ¿Has visto a alguien en la uni hoy?
    Participante: He visto a Marina, la morena.
21. Entrevistador: ¿Y por qué le han condenado?
    Participante: Alzamiento de bienes.
22. Entras en una frutería y el frutero está un poco sordo.
    Participante: Buenas. Quería un kilo de limones.
    Entrevistador: ¿De naranjas?
    Participante: No, de LIMONES.
23. Entrevistador: ¿Qué tal está tu primo?
    Participante: ¿Juan? Bien, de vacaciones en Israel.
24. Entrevistador: ¿Dónde os vais a alojar?
    Participante: En el hotel Urugutu.
25. Entrevistador: ¿Qué tal el examen?
    Participante: Regular. El texto del Cid era muy difícil.

26. Una amiga y tú estáis hablando de unos amigos que se van de viaje. Tú sabes con total seguridad que irán a Lima, pero tu amiga piensa, también totalmente convencida, que irán a Buenos Aires. Dile, seguro, que no, que irán a Lima.
Entrevistador: Que no, que se van a Buenos Aires, estoy seguro.
Participante: ¡Que no, que irán a Lima!
27. Entrevistador: ¿Y cómo dices que se llama la empresa?
Participante: Irutela.
28. Te han encargado comprar un regalo para alguien que no conoces mucho y te da un poco de apuro no comprarlo bien. Dile a la persona que te lo ha encargado que igual no le gusta el regalo que le has comprado.
Puede que no le guste el regalo que le he comprado.
29. Entrevistador: ¿Qué tal con los últimos cambios?
Participante: ¡Estamos todos indignadísimos!
30. Organizas una comida y has decidido cambiar la fecha para que todos los invitados puedan ir. Pregunta si podrán venir si la comida es el primer domingo de mayo.
¿Podréis venir a la comida si la hacemos el primer domingo de mayo?
31. Entrevistador: Así que Clara está embarazada. ¿De quién?
Participante: ¡Sí, mujer, de Guillermo! ¡De quién va a ser!
32. Te invitan a un cocido y es el más bueno que has comido en tu vida, estás encantada.
Entrevistador: ¿Qué tal el cocido, está bueno?
Participante: ¡Está buenísimo!
33. Estás en la calle y pides hora.
33a) Participante: Perdona, ¿me dices la hora?
33b) Participante: Disculpe ¿Tiene hora?
34. Para postre tienes melón y helado. Pregunta a los invitados si quieren melón o helado.
¿Qué queréis, melón o helado?
35. Entrevistador: ¿Qué tal por Asturias?
Participante: Muy bien, pero tenía muchas ganas de visitar Madrid.
36. Entrevistador: Me dice su apellido, por favor.
Participante: Amoretanu.
37. Entrevistador: Voy a ir a ver al tío Carlos.
Participante: Yo también quería ir. ¿Vas a ir hoy o mañana?
38. Tus nietos hacen mucho ruido y no te dejan oír las noticias.
Les pides que se callen.
Callaos un ratito, por favor.
39. No te hacen caso y esta vez lo pides más enfadada.
¿¿¿Os queréis callar???
40. Entrevistador: ¿Qué pasó en el juicio?
Participante: Le absolvieron.
41. Pregunta a tus sobrinos si quieren caramelos.
¿Queréis caramelos?
42. Organizas una fiesta en tu casa y tienes muchas ganas que un compañero tuyo vaya.
¿Vas a venir a la fiesta?? Ya sabes que me encantaría...
43. Necesitas subir tres pisos porque te has dejado el bolso arriba. Vas con un niño pequeño y para ganar tiempo lo dejas abajo.
No te muevas, ¿eh?
44. Necesitas tranquilidad, pero estás en medio de un gran alboroto. Pregunta si alguna vez habrá tranquilidad en este hogar.
¿Habrá alguna vez tranquilidad en este hogar?
45. Entrevistador: ¿Qué cuento le leíste?
Participante: Caperucita y el lobo feroz.
46. Entrevistador: ¿Y qué hace Julio ahora?
Participante: Dirige una empresa en Barcelona. Pero dice que va a entrar en concurso de acreedores.

47. Has subido a Guadarrama a pie. Cuando llegas arriba te encuentras con un compañero y le pides de qué pueblo ha salido él.
Entrevistador: ¡Hombre! ¡Tú también has subido!
Participante: Sí, yo he cogido esta ruta de aquí, ¿y tú? ¿De qué pueblo has salido?
48. Entrevistador: ¿Qué significa CAP?
Participante: Certificado de aptitud pedagógica.
49. Ves que María se está yendo. Pregúntale dónde y cuándo va a volver.
¡María! ¿Dónde vas, y cuándo vuelves?
50. Entrevistador: ¿Tú estás segura?
Participante: Hazme caso, sé de lo que hablo.
51. Entrevistador: ¿Lo has montado tú sola?
Participante: No, con Joaquín.
Entrevistador: ¿Es difícil?
Participante: Si no te saltas ningún paso de las instrucciones es fácil.
52. Entrevistador: pues resulta que ha venido el del gas hoy, y no le he dejado pasar porque no tenía dinero para pagarle. Me ha dicho que mañana volvía.
Participante: ¿Y qué le dirás, si vuelve?
53. Entrevistador: ¿Me concede este baile?
Participante: Con mucho gusto.
54. Tu primo te cuenta que el avión que venía de Barcelona llegó con cuatro horas de retraso. Pídele, sorprendido, a qué hora acabó llegando.
Entrevistador: ¡4 horas de retraso que tuvo el avión!
Participante: ¿¡A qué hora acabó llegando!?
55. Entrevistador: No sabíamos hacerlo, te estábamos esperando.
Participante: ¡Aay! ¿Qué haríais sin mí?
56. Alguien dice algo con lo que estás en desacuerdo y además te parece una barbaridad. Respondes muy enfadada.
Participante: ¡Pero qué atrevida es la ignorancia!
57. Entrevistador: ¿Cómo lo describiría?
Participante: Como una luz cegadora, que se movía muy deprisa.
58. Te dan la hora, pero no acabas de entenderla. Piensas que te han dicho que son las nueve. Vuélvelo a pedir.
¿Qué hora has dicho que son, las nueve?
59. Entrevistador: ¿Comprasteis muchas cosas?
Participante: Un colchón, nada más.
60. Te han preguntado que a dónde vas, pero no sabes si lo has entendido bien. Pregunta si es eso lo que te han preguntado.
¿Qué me has preguntado, que dónde voy?
61. Te han preguntado dónde vas y cuándo volverás, pero no sabes si lo has entendido bien.
¿Qué dices, que a dónde voy y cuándo vuelvo?
62. Entrevistador: ¿Te gusta la salsa?
Participante: Está genial, ¿qué lleva? ¿albahaca?
63. Entrevistador: ¿Pero tú estás segura??
Participante: Confía en mí.
64. Estás buscando a María, pero no la encuentras. Ves a alguien que la conoce y después de hablar un poco sobre ella le preguntas si la ha visto.
Participante: ¿La has visto, a María?
65. Estás hablando de María con alguien y oyes que entra una persona.
Participante: ¿Es María la que ha entrado?
66. Entrevistador: Venga, déjame el coche.
Participante: ¡Déjame en paz! ¡Que te he dicho que no!
67. Estás en el parque con tu nieta, María, y se te escapa. Dile que venga.
Ven aquí, por favor.
68. Salís del parque y se vuelve a escapar. Dile que venga (con más insistencia).
Ven aquí ahora mismo.

69. Ahora estáis en la calle donde pasan coches y se vuelve a escapar. Tú estás muy nerviosa y le dices, enfadada, que venga y que no se separe de ti (con mucha más insistencia).
Ven aquí ahora mismo.
70. Entrevistador: ¿Conoces este libro?
Participante: Sí, lo acabo de leer.
71. Entrevistador: ¿Al cine? No puedo, tengo mucho trabajo.
Participante: Va, vente ...
72. Sigue la escena del cine:
Entrevistador: Me apetece mucho, pero quiero ir adelantando cosas.
Participante: Va, vente, hombre…
73. Entrevistador: ¿Esa es Carmen?
Participante: Sí, ¡mira qué enjoyada va!
74. Entras en la casa de una amiga tuya, Marina, pero al entrar no la ves. La llamas:
¡Marina!
75. Pasan diez segundos y no sale nadie. Vuelve a llamarla.
¡¡Marina!!
76. Entrevistador: Este viernes, ¿qué hacemos al final?
Participante: Lo del concierto gratis suena bien.
77. Estás sirviendo el café y preguntas:
¿El café lo quieres con azúcar o sin azúcar?
78. Entrevistador: Así que Lola ha abierto una empresa que se dedica a la importación.
Participante: No, no. No es de importación, es de exportación.
79. Entrevistador: Hijo, ya que vas al súper, cómprame unos limones.
Participante: ¿Cuántos limones quieres? ¿Tres, cuatro, cinco, seis?
80. Ves algo muy raro, pero no sabes qué es:
Participante: He visto algo. ¿Tú también?
81. Entrevistador: ¿Y esa cara?
Participante: Nos han denegado la subvención.
82. Le dices a tu amiga:
Mira, ha salido el sol.
83. Entrevistador: Si no fueses médico, ¿qué te gustaría ser?
Participante: Actor, o poeta.
84. Entrevistador: ¿te vienes?
Participante: No puedo, tengo mucho trabajo que hacer.
85. Entrevistador: ¿Por dónde has llegado?
Participante: (Estabas muy despistado y no has oído bien la pregunta) ¿Cómo dices, perdón? ¿Por dónde he llegado o por dónde he entrado?
86. Entrevistador: Te pasas tú por el súper, ¿no?
Participante: Bueno. Jamón, salchichón, pescado... lo de siempre, ¿no?
87. Entrevistador: ¿Sabes quiénes van a la fiesta?
Participante: Chema y Fernando seguro. Gema imagino que sí.
Entrevistador: ¿Nadie más?
Participante: Gaspar, depende del curro.
88. Tienes mucha ilusión que alguien venga a una cena que organizas. Se lo pides de manera que no pueda decir que no.
El viernes lo celebramos con una cenita. ¿A que vas a venir?
89. Entrevistador: ¿Sabes? ¡Hoy cumplo 18!
Participante: Ay... juventud dorada... ¡aprovecha!
90. Entrevistador: ¿Diga?
Participante: Hola, soy yo otra vez. ¿Ya ha llegado María?
91. Entrevistador: ¿Cuándo viene Emilio?
Participante: Emilio viene mañana.
92. Nunca antes habías tenido tanto frío.
¡Qué frío hace!
93. Entrevistador: ¿Tú sabes qué edad tiene Concepción Sánchez?

Participante: ¿Conchi? 11 o 12.

94. Entrevistador: ¿Al médico? ¿Qué te pasa?
Participante: Nada, un constipado.

95. Entrevistador: Me voy yendo al bar, ¿vale?
Participante: Espera. Me calzo y te vienes conmigo en coche.

96. Estás en la recepción de un hotel y entra una pareja que quiere una habitación. Diles que rellenen un formulario.
Rellenen este formulario.

97. Ves que están un poco despistados y no lo rellenan. Vuélveselo a decir (con más insistencia).
Rellenen este formulario, por favor.

98. Entrevistador: Jorge viene mañana, ¿verdad?
Participante: No, Emilio, viene mañana.

99. Entrevistador: ¿Te ayudo?
Participante: Sí, enciende la luz del pasillo, por favor.

100. Alguien te tira de la camisa un par de veces, pero cuando tú te giras no ves a nadie. Finalmente, a la tercera vez, ves que es un conocido tuyo muy pesado y hablador que siempre que te ve no te deja ir. Con cara de pocos amigos le preguntas:
Participante: ¿Qué quieres?

101. Estás paseando el perro, Bobi, y se te escapa. Llámalo.
¡Bobi!

102. Entrevistador: Le condenaron a la hoguera, pero no sé por qué.
Participante: Por infiel.

103. Entrevistador: ¿Te ayudo?
Participante: Sí, alcánzame el caldero, que no llego.

104. Entras en una tienda y le preguntas al tendero si tiene mermelada.
Hola. ¿Tiene mermelada?

105. Tu vecina te cuenta que fue a un restaurante a comer y pidió conejo con setas. Ella dice que le dieron liebre en lugar de conejo. No te lo acabas de creer.
¿Qué dices que te dieron?

106. Entrevistador: Y el pasillo, ¿qué tal es?
Participante: Muy ancho.

107. Entrevistador: Pobre Pedro...
Participante: Pues sí, pero después de esto no volverá a ser tan ingenuo.

108. Oye, ¿cómo se llama a las personas de Afganistán?
Participante: ¿De Afganistán? Eh...creo que afganos, no sé.

109. A las dos de la madrugada llaman a la puerta. Estás dormido y te despiertan.
¡¿Quién será a estas horas?!

110. Entrevistador: Que no, de verdad, no, no podemos...
Participante (suplicando): ¿Por qué no venís?

111. Entrevistador: Va, ¡reconócelo!
Participante: ¡No lo voy a admitir porque es mentira!

112. Le pides a un amigo si quiere venir a tomar una limonada contigo.
¿Te vienes a tomar una limonada?

113. Te asombras de ver a la ex de tu amigo y preguntas:
Participante: ¡Mira! ¿Esa no es tu ex?

114. Pides a tu hijo que te ordene la casa y no estás seguro de que lo vaya a hacer ya que no es la primera vez que se lo pides. Pregúntale, medio enfadado, cuándo lo hará.
Ya te he dicho tres veces que limpies la casa ¿Cuándo lo vas a hacer?

115. Entrevistador: ¿Cuántos meses se va a quedar en tu casa?
Participante: Septiembre, octubre y noviembre.

116. Entrevistador: ¿Ya sabes lo que vas a estudiar?
Participante: Ingeniería.

117. Entrevistador: ¿Cuándo lo hacemos?
Participante: Por mí, ahora.

118. Pregunta al entrevistador cómo prefiere que le llamen.

Participante: ¿Cómo te gusta más, Ignacio o Nacho?
119. Entrevistador: ¿Vamos en metro?
Participante: Es tarde, mejor en taxi.
120. Has invitado a un amigo al cine y te ha dicho que no puede venir. Te parece que no lo has entendido bien. Se lo pides para aclararlo.
¿Cómo dices, perdón? ¿Que no vendrás?
121. Entrevistador: ¿Qué hora es?
Participante: Las 5. No, espera, este reloj está atrasado.
122. Entrevistador: ¿Cómo se dice en tu idioma "martillo"?
Participante: Imitikí
123. Entrevistador: ¡Qué contenta te veo!
Participante: ¡La Navidad!
124. Entrevistador: ¿Te vas ya a la cama?
Participante: Sí, voy a leer un poquito.
125. Estás enfermo y esta mañana tuviste que ir al médico. Di que has ido a pesar de la lluvia.
Esta mañana, aunque estaba lloviendo, he ido al médico.
126. Entrevistador: ¿Y Carlos?
Participante: Dice que ahora viene.
127. Entrevistador: Si vas al súper, cómprame unas aceitunas y unas patatitas, porfa.
Participante: Las aceitunas ¿con hueso, o sin hueso, señorito?
128. Entrevistador: Entra un cliente muy importante en tu empresa.
Participante: Señor López, ¿le apetece un vaso de agua?
129. Estás cenando en un restaurante. Hace mucho calor y el ambiente está cargado. A tu lado está tu hijo temblando de frío. Extrañada le preguntas si tiene frío.
¿¡Tienes frío!?
130. Entrevistador: ¿Fumas mucho?
Participante: 10 cigarros al día.
131. Juan ha dicho que iba a venir a merendar, pero quieres confirmarlo. ¿Qué le dices a Juan? (busca confirmación)
Vendrás a merendar, ¿no?
132. Entrevistador: ¿No vas a desayunar nada?
Participante: Hazme un zumo mientras me ducho, porfa, que llego tarde.
133. Estás en casa con tu hija, María, que está mirando la tele. Dile que sales un momento a merendar.
María, salgo un momento a merendar.
134. Entrevistador: Necesito el archivo ya.
Participante: Te acabo de mandar un correo con el archivo adjunto.
135. El electricista tenía que venir a las 10 pero has tenido que ir a comprar y tu hija se ha quedado esperándolo. Al llegar de la compra, el electricista aún no ha venido. Sorprendida preguntas si aún no ha llegado.
¿¡Todavía no ha llegado!?
136. Entrevistador: No me gustó nada el comentario.
Participante: Ni a mí. Me pareció extremadamente cruel.
137. Te encuentras un paquete en tu casa y le preguntas a tu hijo, Mario, quién ha traído esto.
¿Quién ha traído esto, Mario?
138. Entrevistador: ¿Te gustó el italiano? ¿Qué te pediste?
Participante: Comí un plato que se llama Latimo Bolegamo.
139. Entrevistador: ¿Qué has comido hoy?
Participante: Hoy he comido lentejas.
140. Entrevistador: ¿Cuál es el nombre del hijo del elfo Sigurd?
Participante: Éreke.

141. Antes de ir a trabajar tu hermano dijo que no se sentía muy bien. Al volver, lo encuentras en la cama temblando de frío. Ves que no se encuentra bien, pero se lo preguntas sabiendo cuál va a ser la respuesta.
¿No te encuentras bien, eh?
142. Entrevistador: Te veo en la fiesta, ¿vale?
Participante: ¿Viene también el innombrable?
143. Te comentan que una compañera tuya, Marina, quiere ir al baile y tú sabes que no le gusta el baile. No te lo crees y preguntas si de verdad es Marina quien quiere ir.
¿Quiere ir, Marina??
144. Te dicen que un compañero tuyo, Julio, se presenta a alcalde. No te lo crees y lo vuelves a preguntar.
¿Julio, se presenta a alcalde?
145. Entrevistador: ¿Conoces alguna tribu no contactada?
Participante: Sí. Áparata, se llaman.
146. Entrevistador: ¿Has leído algo de Neruda? De tanto ver sus versos en Facebook me están entrando ganas de leer algún libro suyo.
Participante: Sí, es mi poeta favorito.

German sentences set

1. Was macht die Frau auf dem Foto?
Sie trinkt eine Limonade.
2. Was sagt Anna?
Anna sagt, sie hat eine Limonade getrunken.
3. Was macht Maria auf diesem Foto?
Maria isst Mandarinen.
4. Was macht das dunkelhaarige Mädchen auf dem Bild?
Das dunkelhaarige Mädchen isst Mandarinen.
5. Sagen Sie doch mal die Wochentage.
Montag, Dienstag, Mittwoch, Donnerstag, Freitag, Samstag und Sonntag.
6. Was hast du heute gegessen?
Heute hab ich Labskaus gegessen.
7. Du hast gerade jemanden aus Lima kennengelernt. Sag ihm, dass du mal in Lima gewohnt hast.
Echt? Ich hab viele Jahre da gewohnt, in Lima.
8. Du bist zu Hause mit deiner Tochter Maria, die gerade fernsieht. Sag ihr, dass du kurz weggehst, um etwas zu essen.
Maria, ich geh mal was essen.
9. Du bist krank und deswegen bist du zum Arzt gegangen. Sag, dass du dahin gegangen bist, obwohl es geregnet hat.
Heute Morgen, obwohl es echt tierisch geregnet hat, bin ich zum Arzt gegangen.
10. Hast du heute jemanden in der Uni gesehen?
Ich hab Marina gesehen, die Dunkelhaarige.
11. Du willst in einem Obst- und Gemüseladen Zitronen kaufen, aber die Verkäuferin hört schlecht.
A. Guten Tag. Ich möchte ein Kilo Zitronen.
B. Orangen?
A. **Nein, ZITRONEN.**
12. Du kommst in eine Bäckerei, wo es wunderbar nach frischem Brot riecht. Sag es dem Bäcker!
Mhhh! Das Brot riecht ja wirklich wunderbar!
13. Du sprichst mit einer Freundin über ein paar Freunde, die in Urlaub fahren. Du bist absolut davon überzeugt, dass sie nach Lima fliegen. Deine Freundin ist aber davon überzeugt, dass sie nach Buenos Aires fliegen.
Nein, nach Lima fliegen sie!

14. Du wurdest gefragt, ob du für jemanden ein Geschenk kaufen könntest, den du aber nicht gut kennst. Du hast Angst, nichts Passendes zu finden.
Vielleicht gefällt ihm das Geschenk nicht.
15. Clara ist also schwanger?? Von wem?
Ja, klar, von Thorsten! Von wem denn sonst!
16. Du bist zum Spargelessen eingeladen. So leckeren Spargel wie da hast du noch nie gegessen. Was sagst du?
Es ist echt lecker!
17. Dir war noch nie zuvor so kalt wie jetzt. Was sagst du?
Es ist soo kalt!
18. In einem Tante-Emma-Laden fragst du, ob sie Marmelade haben.
Hallo. Haben Sie Marmelade?
19. Du fragst auf der Straße nach der Uhrzeit.
19. A Können Sie mir bitte die Uhrzeit sagen?
19. B Kannst du mir bitte die Uhrzeit sagen?
20. In einer Arztpraxis fragst du, ob du das Behandlungszimmer betreten darfst.
Darf ich eintreten?
21. Im Telefongespräch:
Hallo?
Hallo, ich bin es nochmal. Ist Maria schon da?
22. Du möchtest deine Freunde zum Essen einladen. Du willst den Termin verlegen, damit alle Eingeladenen kommen können.
Könntet ihr zum Essen kommen, wenn wir uns am ersten Sonntag im Mai treffen?
23. Zum Nachtisch hast du Apfelkuchen und Eis. Frag deine Gäste, was sie gerne hätten.
Was möchtet ihr, Apfelkuchen oder Eis?
24. Ich werde Onkel Karl besuchen.
Ich wollte auch zu ihm fahren. Fährst du heute oder morgen?
25. Mario, wenn du (sowieso) schon zum Supermarkt gehst, bring mir mal bitte Zitronen mit.
Wie viele Zitronen denn? 3, 4, 5, 6?
26. Du suchst Gabi, aber du kannst sie nicht finden. Dann siehst du jemanden, der sie kennt. Nachdem ihr ein bisschen über sie gesprochen habt, fragst du ihn, ob er sie gesehen hat.
Hast du sie gesehen, die Gabi?
27. Du sprichst mit jemandem über Gabi. Du hörst, wie jemand reinkommt.
Ist das Gabi, die gerade reingekommen ist?
28. Der Termin mit dem Elektriker war um 10 Uhr. Du musstest aber einkaufen, und deine Tochter ist zu Hause geblieben, um auf ihn zu warten. Als du zurückkommst, ist er immer noch nicht aufgetaucht. Überrascht fragst du:
Ist er immer noch nicht gekommen??
29. Beim Essen in einem Restaurant ist es sehr heiß und stickig. Neben dir zittert dein Sohn vor Kälte. Überrascht fragst du:
Ist dir etwa kalt?
30. Lukas hat gesagt, dass er zum Abendessen kommt, aber du möchtest nochmal sichergehen. Was sagst du Lukas?
Du kommst zum Abendessen, oder?
31. Bevor du zur Arbeit gegangen bist, hat dein Bruder dir gesagt, dass er sich nicht gut fühlt. Wieder zu Hause angekommen, findest du ihn zitternd vor Kälte im Bett. Du weißt schon die Antwort. Trotzdem fragst du:
Dir geht's nicht gut, oder?
32. Du freust dich sehr, dass jemand zu einem Abendessen kommt, das du vorbereitest. Frag ihn so, dass er nicht Nein sagen kann.
Am Freitag feiern wir das mit einem Abendessen. Du kommst doch, oder?
33. Du weißt nicht, ob es heute kalt draußen ist oder nicht. Es kommt jemand rein, der warm angezogen ist, und du fragst ihn, ob ihm kalt sei.
Ist dir kalt?

34. Deine Enkel sind zu laut. Deswegen kannst du die Nachrichten nicht hören. Sag ihnen, dass sie leise sein sollen.
Könnt ihr mal ruhig sein?
35. Sie hören nicht auf dich. Dieses Mal sagst du ihnen:
Seid ihr jetzt endlich mal still!?
36. Frag einen Freund von dir, ob er mit euch ein Bier trinken gehen will.
Willst du mitkommen, zum Biertrinken?
37. Frag deine Neffen, ob sie Bonbons möchten.
Wollt ihr Bonbons?
38. Du machst eine Party bei dir zu Hause und du würdest dich sehr freuen, wenn ein Kollege von dir käme.
Kommst du zur Party? Du weißt doch, wie sehr ich mich freuen würde.
39. Du musst in den dritten Stock, weil du da deine Tasche vergessen hast. Du hast ein kleines Kind bei dir. Um Zeit zu sparen, lässt du es unten.
Du bleibst hier stehen, ja?
40. Du brauchst Ruhe, aber es ist sehr laut um dich herum. Frag, ob es irgendwann mal endlich leise in diesem Haus sein wird.
Ist es hier irgendwann eigentlich mal ruhig?!
41. Auf der Straße fragst du eine Person in deinem Alter, wie spät es ist.
Wie spät ist es?
42. Frag einen alten Menschen, wie spät es ist.
Könnten Sie mir sagen, wie spät es ist?
43. Du hast zu Fuß einen Berg bestiegen. Es gibt verschiedene Wanderwege. Auf dem Gipfel triffst du einen Kollegen. Frag ihn, welchen Weg er genommen hat.
Hallo! Ich hab den Wanderweg da genommen, und du? In welchem Dorf bist du losgegangen?
44. Hanna macht sich gerade auf den Weg. Frag sie, wohin sie geht und wann sie zurück ist.
Hanna! Wohin gehst du und wann bist du wieder da?
45. Die Sache ist die: Heute ist der Gasmann gekommen, aber ich hab ihn nicht reingelassen, weil ich kein Geld hatte. Er hat gesagt, er kommt morgen wieder.
Und was sagst du ihm morgen, wenn er wiederkommt?
46. Zuhause findest du ein Paket vor. Du fragst deinen Sohn, Jürgen, wer das hier abgegeben hat.
Wer hat das hier abgegeben, Jürgen?
47. Dein Cousin erzählt dir, dass sein Flug von Frankfurt vier Stunden Verspätung hatte. Du bist überrascht und fragst ihn, wann der Flug letztendlich angekommen ist.
Wann ist er denn angekommen??
48. Um 2 Uhr nachts klingelt jemand an der Tür. Du schläfst und wirst dadurch aufgeweckt.
Wer ist das um diese Zeit?
49. Du hast deinem Sohn schon drei Mal gesagt, dass er sein Zimmer aufräumen soll. Du bist nicht sicher, ob er es tun wird, weil du ihn nicht zum ersten Mal darum bittest. Frag ihn ein bisschen sauer, wann er es machen wird.
Ich hab dir schon drei Mal gesagt, dass du das Zimmer aufräumen sollst. Wann machst du das endlich mal?
50. Deine Freunde sagen, dass sie nicht zur Party kommen können. Du findest das ziemlich schade und fragst noch mal nach.
Nein... wirklich, wir können nicht...
(inständige bitte) Warum kommt ihr denn nicht??
51. Jemand zieht dir mehrmals am Hemd, aber als du dich umdrehst, siehst du niemanden. Endlich, beim dritten Mal, siehst du, dass es ein Bekannter von dir ist, der sehr nervig und redselig ist. Du bist ziemlich genervt und fragst ihn.
Was willst du, Mann?
52. Du hast deinen Mitbewohnern schon 1000 Mal erklärt, wie man die Waschmaschine bedient. Jetzt kommst du nach Hause und die Wäsche ist wieder mal nicht gewaschen. Einer von beiden sagt: “Wir haben das nicht hingekriegt. Da haben wir lieber auf dich gewartet.” Du erwiderst:
Was würdet ihr ohne mich machen?!

53. Du hast einen Freund ins Kino eingeladen und er sagte, dass er nicht mitkommen kann. Du bist nicht sicher, ob du alles richtig verstanden hast.
Wie bitte, du kommst also nicht mit?
54. Eine Frau sagt dir, wie spät es ist. Du glaubst, sie sagte, es ist 9 Uhr, aber du konntest es nicht ganz verstehen. Frag nochmal.
Wie bitte, 9 Uhr?
55. Du hast akustisch nicht verstanden, ob die Frage war, wohin du gehst.
Was hast du gefragt? Wohin ich gehe?
56. Jemand fragte dich, wohin du gehst und wann du zurück bist. Aber du bist nicht sicher, ob du es richtig verstanden hast.
Was hast du gefragt? Wohin ich gehe und wann ich zurück bin?
57. Jemand hat dich gefragt, wo du angekommen bist, aber du weißt nicht genau, ob er dich das gefragt hat oder ob er dich gefragt, wo du reingekommen bist. Frag, ob er dich das eine oder das andere gefragt hat.
Was willst du wissen? Wo ich angekommen bin oder wo ich reingekommen bin?
58. Man hat dir erzählt, dass eine Freundin von dir, Marina, tanzen gehen will. Du weißt aber, dass ihr Tanzen keinen Spaß macht.
Will sie das wirklich machen, Marina??
59. Eine Freundin erzählt dir, dass Rita als Bürgermeisterin antritt. Du glaubst, das kann nicht wahr sein:
Rita, als Bürgermeisterin?
60. Deine Nachbarin erzählt dir, dass sie ins Restaurant gegangen ist und Kaninchen mit Pilzen bestellt hat. Sie sagt, dass sie ihr dort statt einem Kaninchen eine Katze serviert haben. Du kannst das nicht glauben.
Was sagst du, was sie dir serviert haben??
61. Du bist Empfangschef/dame eines Hotels und ein Paar kommt ins Hotel rein. Sag ihnen, sie müssen das Formular ausfüllen.
Füllen Sie bitte dieses Formular aus.
62. Die beiden sind woanders mit ihren Gedanken und füllen es nicht aus. Bitte sie nochmal darum.
Füllen Sie doch mal dieses Formular aus, bitte.
63. Du bist im Park mit deiner Enkelin, Michaela, und sie läuft weg. Sag ihr, dass sie zurückkommen soll.
Komm bitte zurück!
64. Als ihr aus dem Park rausgeht, läuft sie schon wieder weg. Sag ihr noch bestimmter, dass sie zurückkommen soll.
Komm jetzt bitte sofort wieder her!!
65. Jetzt seid ihr auf der Straße, wo die Autos langfahren, als sie wieder weg läuft. Du hast Angst, dass ein Unfall geschieht, und bist zugleich etwas genervt und rufst ihr hinterher:
Komm jetzt sofort wieder her!!!
66. Dein Hund Bobi läuft weg. Ruf ihn.
Bobi!
67. Dein Freund sagt, er könne nicht ins Kino mitkommen, weil er noch so viel zu tun habe. Du willst ihn überreden und sagst:
Jetzt komm schon, bitte!
68. Er sagt, er wolle eigentlich schon gerne mitkommen, aber er müsse echt noch ein paar Sachen im Voraus erledigen. Du bittest ihn nochmal:
Oh, komm mal, Mann!
69. **Du bist in Leas Haus reingegangen, aber du kannst sie nicht sehen.**
Lea!
70. 10 Sekunden vergehen und keiner kommt. Ruf sie nochmal.
Lea!!
71. Du schenkst Kaffee ein und du fragst:
Den Kaffee mit oder ohne Zucker?
72. Ein Freund behauptet, dass Klara jetzt eine Importfirma aufgemacht hat. Du klärst ihn auf:
Nein, nein. Keine Importfirma, eine Exportfirma.

73. Du hast etwas Komisches gesehen, aber du weißt nicht genau, was.
Ich hab was gesehen. Du auch?
74. Sag deiner Freundin:
Guck mal, die Sonne ist rausgekommen.
75. Ein Freund von dir fragt dich, ob du mit ins Theater kommst. Du sagst ihm, dass du leider nicht kannst, weil du noch viel zu tun hast.
Leider nicht, ich hab viel zu tun.
76. Ein Freund von dir fragt dich, wann Guido kommt.
Guido kommt morgen.
77. Dein Mitbewohner behauptet, dass Saskia morgen kommt. Du weißt, dass das nicht stimmt und dass stattdessen Carsten kommt.
Nein, Carsten kommt morgen.
78. Werner hat ein Buch über Mozart geschrieben?
Gerd hat ein Buch über Mozart geschrieben.
79. Gerd hat einen Artikel über Mozart geschrieben?
Gerd hat ein Buch über Mozart geschrieben.
80. Gerd hat ein Buch über Mozart gelesen?
Gerd hat ein Buch über Mozart geschrieben.
81. Tag Tim, ziemlich kühl, oder?
Quatsch! Ich hab schon Schlimmeres erlebt!
82. Was machen Sie hier??
Das Tor stand auf. Da bin ich einfach mal reingegangen.
83. Mit wem machst du denn Urlaub?
Mit meinem Kollegen.
84. Es tut mir leid!
Keine Sorge!
85. Du siehst nicht sehr gut aus.
Ja. Ich hab Kopfschmerzen und mir ist schlecht.
86. Wieso kannst du Arabisch verstehen??
Als Kind hab ich in Libyen und Syrien gewohnt.
87. Was studiert Klaus?
Psychologie oder Chemie, keine Ahnung.
88. Wieso fliegt sie nach Kigali?
Sie muss was präsentieren, Ökologie in Afrika oder sowas ähnliches.
89. Was macht Rita jetzt?
Sie arbeitet an einer Universität, in Amerika. Ich weiß aber nicht genau, wo.
90. Ein bisschen teuer, oder?
Nein, das ist für ein Doppelzimmer und für das Essen im Restaurant vom Hotel.
91. Deine Eltern wohnen in Österreich, ne?
Nein, die wohnen in der Schweiz aber die machen Urlaub in Österreich.
92. Hast du die Geschenke für Lea schon gekauft?
Ja, schau mal. Diese zwei Bücher und ein Parfum.
93. Er geht mir auf die Nerven!
Na ja, man muss ihn nehmen, wie er ist.
94. Hast du schon alles?
Kartoffeln, Mayonnaise, Senf, rote Beete und Öl. Was brauchen wir noch?
95. Schatz, bin ich dick?
Neeein! Du hast nur eine üppige Figur!
96. Ok, aber wo?
Irgendwo im Süden von Skandinavien.
97. Welcher gefällt dir am besten?
Ich weiß nicht, ich finde beide Käse ziemlich ähnlich.
98. Erinnerst du dich?
Das könnte ich nie vergessen.
99. Tolles Foto, wo warst du denn?

In einer Stadt in der Nähe vom Roten Meer. Sehr schön.
100. Es ist eine gute Möglichkeit.
Ich weiß... aber du wirst uns fehlen.
101. Bitte...
Es tut mir leid, aber es ist einfach nicht möglich.
102. So viele Menschen helfen ihnen.
Stimmt, aber wie Max sagt, Gnadenbrot ist keine gute Lösung.
103. Bis später!
Bis später! Vergiss nicht, einen Knopf zu kaufen, bitte! Tschüss!
104. Hast du gehört??
Pfui! Die Engländer...
105. Wir könnten etwas für das Wochenende organisieren?
Ja! Vielleicht einen Ausflug.
106. Einen Ausflug? Wohin?
Schau mal dieses Angebot: "Passau entdecken: 97 €"
107. Funktioniert nicht?
Nein... "Außer Betrieb"
108. Alles in Ordnung da?
Im Prinzip ja, aber...
109. Heute ist es echt kalt, oder?
Ja! Wollen wir eine Suppe machen?
110. Ich hab eine.
Gib mal!
111. Schau mal.
Toll. Du bist ein Genie.
112. Nummer 37, was noch?
2. Etage.
113. Glaubst du ihnen nicht?
Nee, die lügen echt wie gedruckt!
114. Diese?
Nein, nicht die blauen, sondern die grünen.
115. War's schön beim Italiener? Was hast du bestellt?
Ich hab was gegessen, das Latimo Bolegamo heißt.
116. Wie heißt denn die Stadt, wo ihr Urlaub macht?
Oromaluco.
117. In welchem Hotel kommt ihr unter?
Im Hotel Urugutu.
118. Wie heißt die Firma denn?
Irutela.
119. Ihre Nachname, bitte.
Amoretanu.
120. Woher kommen die Außerirdischen aus dem Film von Spielberg?
Vom Planeten Orotomo.
121. Wie sagt man "Hammer" in deiner Sprache?
Imitiki.
122. Wie heißt der Sohn vom Elf Sigurd?
Ereke.
123. Kennst du einen Stamm ohne Kontakt mit der Zivilisation?
Ja. Aparata

Tokens analysed per language and sound-class:

The numbers refer to the order the sentences occupy in the Spanish and German sets.

Spanish

Vowels
Stressed /a/
48, 51, 62, 66, 114
Stressed /e/
1, 8, 11, 25, 30
Stressed /i/
10, 25, 33, 45, 124
Stressed /o/
22, 59, 86, 118
Stressed /u/
53, 77, 127, 132
Unstressed /a/
8, 45, 51, 66
Unstressed /e/
1, 8, 10, 28
Unstressed /i/
32, 33, 51, 76
Unstressed /o/
4, 53, 58, 84
Unstressed /u/
24, 27, 31, 45

Stops
Initial position:

	/p/	/b/	/t/	/d/	/k/	/g/
/a/	Paco	barco	talco	dardo	carta	gato
/e/	pecho	beso	tele	dedo	queso	guerra
/i/	piso	vista	tilde	disco	Kilo	guiso
/o/	pollo	bollo	tonto	dólar	coche	gota
/u/	pulso	buho	turno	duque	cura	gusto

Word-medial intervocalic unstressed:
/b/: 3, 42; /d/: 30, 47; /g/: 25, 132
/p/: 45, 128: /t/: 124, 127; /k/: 54, 62

Fricatives
Intervocalic unstressed /s/
7, 32, 35
Intervocalic unstressed /θ/
85, 114, 127
Intervocalic unstressed /f/
45, 48, 97
Intervocalic unstressed /x/
66, 84, 139

Rhotics
Intervocalic unstressed /r/
121, 130
Intervocalic stressed /r/

47, 134
Intervocalic unstressed /ɾ/
1, 45, 54, 58
Intervocalic stressed /ɾ/
9, 20, 22, 65

German

Vowels
Stressed /a:/
19a, 19b, 26, 27
Stressed /a/
29, 40, 52, 60
Stressed /ɛ/
6, 16[2], 30, 106
Stressed /ɛ:/
4, 41, 97[2], 103
Stressed /e:/
26, 39, 73, 83
Stressed /œ/
22, 23, 42, 98
Stressed /ø:/
91, 99, 101, 102
Stressed /ɪ/
19a, 36, 86, 90
Stressed /i:/
5, 13, 48, 88
Stressed /ʏ/
38, 46, 59, 95, 103
Stressed /y:/
86, 92, 96, 113
Stressed /ʊ/
10, 71, 74, 109
Stressed /u:/
23, 75, 78, 102
Stressed /ɔ/:
5[2], 32[2]
Stressed /o:/
5, 11, 12, 25
Unstressed /ə/
2, 4, 84, 107
Unstressed /ɐ/
12, 16, 107

Stops
Initial position:

	/p/	/b/	/t/	/d/	/k/	/g/
/a:/	Pater	Bahnen	Tafel	Dame	Kabel	Gabel
/e:/	Pegel	Beete	These	Demo	Kegel	Geben
/ø:/	pöbeln	Böden	töten	dösen	König	Goethe
/i:/	piepen	Biene	Tiefe	Diesel	Kiefer	gießen
/o:/	Polen	Bohrer	toben	Dose	Kohle	Gotik
/u:/	Puma	buhen	tuten	Dusche	Kugel	Gutenberg
/y:/	Phython	Bücher	Type	Düne	kühlen	Güte

Word-medial intervocalic unstressed:
/b/: 26, 86; /d/: 1, 2; /g/: 4, 10
/p/: 90, 95; /t/: 53, 54; /k/: 16, 71

Fricatives
Unstressed intervocalic /s/
30, 98, 107
Unstressed intervocalic /z/
61, 62
Unstressed intervocalic /ʃ/
14, 21, 99
Unstressed intervocalic /ʒ/
112
Unstressed intervocalic /f/
22, 71, 94
Unstressed intervocalic /v/
88, 89, 96
Unstressed intervocalic /ç/
23, 88
Unstressed intervocalic /x/
92, 94
Unstressed intervocalic /χ/
52, 58

Róticas
Intervocalic stressed /ʁ/
3, 8, 10, 21
Intervocalic unstressed /ʁ/
7, 86, 89, 91