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A cross-linguistic study of voiceless fricative sibilants in Galician and European Portuguese[1]

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1. Introduction

The first spectrum analyses of fricative consonants were undertaken at an early date (Hughes and Halle, 1956, Heinz and Stevens 1961), but studies that ushered in important breakthroughs began to be published mainly with Forrest et al. (1988). Most such studies examine English fricatives (see Gordon et al. 2002: 141 and the references there), although other languages have been considered more recently. Gordon et al. (2002) surveys fricatives in seven languages from different language families, while Żygis (2010) examines five Slavic languages. More recently, fricatives in other languages such as Welsh (Jones and Nolan 2007), Belarusian (Zeller 2011) and Greek (Nirgianaki 2014) have been examined.

There have been few studies of fricatives in Romance languages. Portuguese was covered by Lacerda (1982), an acoustic-perceptive study; Jesus and Shadle (2002); and a paper by Andrade and Slifka (2005). For Galician, following descriptive studies using spectograms and LPC which produced few conclusive results (Martínez Mayo 2000, Formoso 2001, Rodríguez 2002), Labraña (2005, 2009, 2014) carried out a larger-scale study of fricatives in several regions of Galicia, differentiating between [ʃ] and three types of [s], which are identified with two places of articulation: apical and lamino-alveolar. Regueira (2014), using spectral profiles and centre of gravity calculations, examined variation in fricative realization in a variety of Galician which has both

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laminal alveolar [s] and lamino-dental [s̪] fricatives, as well as the lamino-postalveolar [ʃ].

In this paper we will examine the Galician and Portuguese voiceless fricative sibilants using a broader sample of informants than is usual in such studies. While Andrade and Slifka (2005) had two informants, Jesus and Shadle (2002) had four, and Labraña (2005ff) had ten, we used 17 Galician speakers and 22 Portuguese speakers (see section 2). One of our objectives, then, is to study intralinguistic variation in the production of these fricatives, which is something not yet widely studied using acoustic methods. This will also make comparisons possible between Galician and Portuguese.

Such a comparison is of interest in itself given the close relationship between these two languages. It is precisely in their phonological and phonetic system where they diverge most obviously (Álvarez Blanco 1991). Traditional dialectology has shown that there is a territorial continuity between Galician and Portuguese regarding phonological and lexical features (Cintra 1971, Álvarez Pérez 2010); that information has been supplemented and updated in papers such as Dubert and Sousa (2002), Álvarez Pérez (2014, 2015), among others. Recent studies comparing aspects of Galician and Portuguese phonetics including unstressed final vowels (Regueira 2007), nasalization (Regueira 2010) and intonation (Moutinho et al. 2009, Fernández Rei et al. 2014, and others), have revealed complex relationships involving some similar behaviours and continuities between the two languages but also some rather divergent ones. This is hardly surprising in view of the contrasting sociolinguistic situations of the two languages (Galician is treated as a minority language in relation to Spanish, whereas Portuguese is the official language of a state), yet the survival of continuities despite centuries of linguistic isolation between the language communities is worthy of scholarly attention.

We shall see in section 2 that there are also such partial continuities in the system of sibilants, but that features diverging from standard Portuguese are receding or disappearing. The sibilant systems of certain Galician varieties that are similar to forms of Portuguese in some respects are losing ground in Galicia, as they are being replaced by the standard Galician system and influenced by Spanish.

In this project, rather than focusing on the most conservative forms, we studied young university students (except for two of the Galician speakers). Our informants are native speakers of one of the two languages examined who come from a variety of places in Galicia and the north of Portugal. This information will allow us to ask whether the shift from local language varieties to the standard language is already

complete, or whether, on the contrary, the uniform descriptions given of the standard varieties conceal a significant degree of variation in the realization of sibilants.

2. Galician and Portuguese sibilants

One of the most striking divergences in the development of Galician and Portuguese concerns the system of sibilant fricatives. Two distinct systems have emerged in Portuguese and Galician (see for example Lorenzo 1995; Cardeira 2003). Table 1 summarises these divergent developments.

Table 1: Development of the sibilant system from medieval Galician-Portuguese to standard modern Portuguese and Galician.

Galician-Portuguese (medieval)		*Portuguese (standard)*		*Galician (standard)*
Voiceless	*Voiced*	*Voiceless*	*Voiced*	*Voiceless*
[t͡s] > [s] *paço* ‘mansion’	[d͡z] > [z] *cozer* ‘to boil’	**[s]** *paço* *passo*	[z] *cozer* *coser*	[θ] *pazo, cocer*
[s̪] *passo* ‘step’	[z̪] *coser* ‘to sew’			[s̪] *paso, coser*
[ʃ] *queixo* ‘chin’	[ʒ] *queijo* ‘cheese’	[ʃ] *queixo*	[ʒ] *queijo*	[ʃ] *queixo, queixo*

As Table 1 shows, present-day Portuguese has two pairs of sibilants differentiated by place of articulation and voicing, while Galician has three fricatives and no voicing opposition. In both languages there is no phonological contrast in coda position, where in Portuguese a palatal [ʃ] is found, whereas in Galician usually an apical [s̪] appears.

The dialect situation is more complex than that shown in the table. Portuguese [s] and [z] are usually described as predorso-alveolar (Barbosa 1994: 63) or lamino-alveolar (Emiliano 2009: 40), although Mateus and d’Andrade (2000: 13) state that they are “produced in the dento-alveolar region.” There are, however, conservative dialects in the north of Portugal that still have a system that is similar to the medieval one, with two pairs of sibilants in the alveolar region: “a laminal pair and an apical pair… In terms of the passive articulators, it is said that the former are dental ([s̪], [z̪]) and that the

latter are alveolar" (Mateus and d'Andrade 2000: 13). This system is one of the features used by Cintra (1971) to draw the boundaries between dialect varieties in the north of the continental Portuguese language area, although he also records another system with a single pair of voiceless and voiced apico-alveolar sibilants (p. 110). Cintra's data, which are from the surveys of the *Atlas Lingüístico de la Península Ibérica* (ALPI), were checked by Álvarez Pérez (2015), who shows that the vitality of the apico-alveolar pronunciations is unequal and often limited, in these data collected in Portugal between 1953 and 1956. Comparison with the data collected for the *Atlas Linguarum Europae* (ALE) (in surveys carried out in 1975) by Martins and Saramago (1993) shows the four-sibilant system to be receding so fast that it was only recorded as stable in two localities. The twenty-two informants consulted for our study are from areas in northern Portugal including many of the districts formerly noted as retaining apico-alveolar sibilants. However, when asked about differences between the speech variety of their home district (such as Chaves, Bragança, Barcelos, Montalegre, Pinhel) and standard Portuguese, they mentioned the lack of a /b/ : /v/ opposition and some other phonetic features almost unanimously, yet showed no awareness of any difference in the pronunciation of sibilants, even when asked directly.

The situation in Galician with regard to the sibilants is complicated too. Besides the standard system with /θ/ (see Table 1), where the alveolar sibilant is always described as apical (e.g. *Atlas Lingüistico Galego*, Regueira 1998, Álvarez and Xove 2002), there are other systems including that which Fernández Rei (1991: 193) calls "Galician with predorso-dental *seseo.*" These varieties only present two sibilants: a lamino-alveolar /s/ (as in *caza, casa*) and a lamino-postalveolar /ʃ/ (as in *caixa*); in word-final position the apico-alveolar realization [s̻] (*voz, vós*) is usually found, although in some places an apico-postalveolar fricative occurs (González 1991), represented by [ʂ] (Vidal 1993). So in this respect, the system resembles standard Portuguese except for the lack of a voice opposition (note also that [s̻] is auditorily and acoustically very similar to [ʃ], see 4.4). This system has been observed to be very unstable (González 1991), and shows a tendency to depalatalize the post-alveolar fricative ([ʃ] > [ʂ] ~ [s̻]). In another study (Regueira 2014), realizations of the front sibilant in this area were shown to exhibit important variations both in syllable onset and coda. In onset position one mostly finds lamino-alveolar sibilants, with some speakers also using lamino-dental pronunciations. Syllable-finally, fricatives close to [ʃ]

appear, corresponding to apico-alveolar and apico-postalveolar realizations, while other speakers had fricatives similar to [s].

Important changes are taking place in these dialects which affect the sibilant system (González 1991, Regueira 2009, 2014), involving social and economic changes that these communities are undergoing, along with increasing contact with both standard Galician and Spanish (Regueira 2013). The sibilant system called *seseo* is one typical feature of dialect speech, especially when rural; within those speech varieties the alveolar-dental realizations are even more stigmatized. Given that, as seen, the Portuguese region is also undergoing replacement of local speech varieties by a standard variety, linguistic diversity in this area is rapidly diminishing as the society is increasingly urbanized and traditional culture is being replaced by new lifestyles.

Thus, the continuity between Galician and Portuguese language forms which still existed in the rurally-based traditional culture, as registered in standard works of dialectology (such as the language atlases and studies of rural speech produced in past decades) is disappearing to a great extent. One interesting aspect of the present study is the insight it provides into how phonetic differences across the border are being intensified by these cultural and social changes.

3. Method

3.1. Questionnaire and informants

For this study, Galician speakers recorded answers to a questionnaire which aimed to detect the pronunciation of fricatives corresponding to /θ/, /s̟/ and /ʃ/ in initial position before five stressed vowels: /i, a, u/ (*cinco* ‘five’, *sidra* ‘cidre’, *xira* ‘(it) spins’, etc.) and one of the front and back mid vowels /e, ɛ/, /o, ɔ/ (*cero* ‘zero’, etc.), due to the scarcity of examples preceded and followed by low-mid and by high-mid vowels; in intervocalic position preceded and followed by the same vowel (/i_i/, etc.), wherever possible, with stress on the second vowel (*oficina* ‘office’, *invisible, corrixir* ‘to correct’, etc.). Fricatives were also recorded in word-final position in the coda of stressed syllables (*nariz* ‘nose’, *anís* ‘anisette’, etc.). Each word was repeated twice, so we obtained 10 samples of each sibilant in initial position, 10 in medial position and 10 in final position. In areas that have *seseo*, given that the realizations corresponding etymologically to /θ/ and /s̟/ constitute a single sibilant (Regueira 2014), the number of tokens of that sibilant is doubled. With Portuguese speakers we made up a questionnaire following similar

criteria, and obtained from each informant 40 tokens of the front sibilant, 20 of [ʃ] and 20 of the sibilant in final coda position.

The informants for this study are young people from different places, preferably small towns and villages, with a university education. They are all speakers with intense exposure to the standard language both as students and in their day-to-day life. The only exceptions are two Galician informants who, in a previous study (Regueira 2014), were found to be resistant to change and maintain the traditional system of their area even though their lifestyle is no longer the traditional one: they are members and employees of a modern agricultural firm. They were included in the study so that we could compare their realizations of the variety with *seseo* with those of other Galician and Portuguese informants.

There were 17 Galician informants (nine women and eight men) aged between 22 and 35. Given the dialect situation described above, we chose eight individuals (four women and four men) from the *seseo* area located in the west of Coruña province (from the town districts of Dumbría, Mazaricos and Negreira). The other seven informants represent other areas: A Terra Chá (in Lugo province), Santiago de Compostela and Touro (in Coruña province), Leiro and Xinzo de Limia (in Ourense province), and Hermisende (in Zamora). The two places mentioned last are both located near the Portuguese border.

Informants were asked to use their usual informal pronunciation in their regional or local dialect variety. But in Galicia there is strong awareness among speakers from the *seseo* area of the stigma attached to that pronunciation, seen as typifying the rural speech of the area. Some of the informants even told us they felt uncomfortable using that variety in the recording. Hence, to avoid the risk that reading the questionnaire might tend to favour the production of responses in standard Galician, replies were elicited using pictures (showing a picture and asking “What is that?”, or “What is it/he/she doing?”). In the Portuguese area there were 22 informants (11 women and 11 men) who were university-educated, aged between 19 and 33, 19 of whom came from districts in the north of Portugal (Braga, Vila Real, Bragança, Porto, Aveiro, Viseu and Guarda) and three from the centre of the country (Leiria, Santarém and Lisboa districts). In this case words were read from a list, since the informants themselves did not perceive any difference between their fricatives and those of the standard language; it has been shown in other studies that Portuguese speakers do not modify their pronunciation of these fricatives when reading (Martins and Saramago 1994: 125).

3.2. Procedure

The recordings were made using a Shure SM10A headset microphone and a Marantz PDM671 recorder with a sampling frequency of 24 kHz, 16 bits. Acoustic analysis was carried out using the Kay Elemetrics Multi-Speech 3700 platform.

For each sample, we did a 40 ms spectrum of the central part of the fricative, from 0 to 12 kHz. Although some studies indicate that sibilant articulation is dynamic in nature, i.e. sibilants vary both articulatorily and acoustically in the course of their production, they have also found this variation to be less pronounced in syllable-initial position (Munson 2001) and it has been demonstrated that the articulatory organs reach their closest point at the centre of the sibilant (Iskarous et al. 2008). Shadle and Mair (1996) have shown that in intervocalic position sibilants' centre of gravity remains fairly constant, and Iskarous et al. (2011) say that in prevocalic position the degree and location of closure stay relatively constant all the way to the end of the consonant (studying the production of /s/ in English). In her study of Greek fricatives, Elina Nirgianaki (2014), following an analysis of the results for different moments in three windows (at the beginning, middle and end of the fricative), concludes that "[i]n general, across moments, window location 2 (middle) contained the most distinctive information regarding the fricative place of articulation [sic]" (p. 2970). Using a 40 ms window at the centre of the fricative, Jongman et al. (2000) were able to distinguish the place of articulation of English fricatives, as did Zeller (2011) for Belarusian, Gordon et al. (2002) for seven languages from different families, and as we have done in a previous study of Galician fricatives (Regueira 2014).

The spectra were obtained by FFT. Each spectrum is treated as a random probability distribution, the first four moments of which were calculated (center of gravity, variance, skewness and kurtosis). But in line with the findings of Forrest et al. (1988) and subsequent studies, we focused on the study of the first moment, i.e. the spectral mean or centre of gravity. Although only a rude measure, this parameter has proved itself an efficient indicator for differentiating sibilants. Various studies have shown that alveolar sibilants present a higher spectral mean than postalveolars (Nittrouer et al. 1989, Shadle and Mair 1996, Jongman et al. 2000, Gordon et al. 2002, Jones and Nolan 2007, Maniwa and Jongman 2009, Żygis 2010, Nirgianaki 2014).

Although most of these studies only examine the contrast between /s/ and /ʃ/, some recent work also examines other fricatives. Zeller (2011) examines different realizations of sibilants by Belarusian speakers influenced by Russian, in particular the production of [s], [sʲ], [tʲ], [tʃʲ] and [ʂ], while Żygis (2010) manages to differentiate between [ʃ] and [ʂ] using the spectral mean.

We have departed in this respect from the procedure used by Labraña (2005, 2009, 2014), who uses LPC with a 6-pole filter. She is able to distinguish efficiently between /ʃ/ and /s/-type fricatives as well as the sibilant in final position. Since LPC calculations tend to emphasise contextual variation, we opted to use spectra and spectral moments, following in the line of most fricative studies and also our previous study Regueira (2014), in order to make it possible to carry out comparisons with other languages for which data are available.

4. Findings and discussion

4.1. Groups by sex

A number of studies point to the existence of substantial differences between the fricative sounds produced by men and women, particularly in the sibilants. In a groundbreaking paper, Schwartz (1968) proved that hearers could distinguish the sex of a speaker by listening to isolated samples of voiceless sibilants, since those produced by women had higher frequencies than those of men. Later studies found spectral differences between sibilants produced by female and male speakers (e.g. Jongman et al 2000: 1256; Gordon et al. 2002: 144). These differences are usually accounted for by the size of the vocal tract, a biological factor, but it was also shown that the differences are affected by socio-phonetic (i.e. social and cultural) factors (Fuchs and Toda 2010; Munson et al. 2006).

Our results, shown in Table 2, contain no surprises in this respect (cf. also the findings of Regueira 2014).

Table 2: Spectral mean and standard deviation (all informants) for each sibilant (initial and intervocalic positions pooled together) separated by sex (SF represents all realizations of sibilants in word-final position).

	Spectral Mean (Hz) Female	Std Dev (Hz)	Spectral Mean (Hz) Male	Std Dev (Hz)	Student t	p-value
[s]	6843	1678	5979	1804	7.152	<.0001
[ʃ]	4412	930	3439	617	13.738	<.0001
[SF]	4828	1095	3476	954	15.463	<.0001

In all cases, the frequency values are higher for the female groups than for male speakers and the differences are statistically significant. Given these results, comparisons will always be between same-sex groups.

4.2. Alveolar and postalveolar sibilants

The behaviour of postalveolar sibilants is fairly uniform among speakers, and the two languages also resemble each other to a considerable extent with regard to both spectra and spectral moments. On the other hand, there are marked differences when it comes to the alveolar sibilants (see Table 3).

Table 3: Spectral mean and standard deviation for alveolar and postalveolar fricatives in Galician and Portuguese male and female groups (G = Galician, P = Portuguese, F = Female, M = Male)

Groups Galician	Spectral Mean (Hz)	Std Dev (Hz)	Groups Portuguese	Spectral Mean (Hz)	Std Dev (Hz)	Student t	p value
[s] GF	6022	1455	[s] PF	7664	1475	-8.707	<.0001
[s] GM	4696	1401	[s] PM	7263	1121	-15.513	<.0001
[ʃ] GF	4209	992	[ʃ] PF	4614	819	-3.470	0.001
[ʃ] GM	3238	611	[ʃ] PM	3641	557	-5.490	<.0001

For postalveolar sibilants [ʃ] Galician informants have slightly lower values than Portuguese speakers, but the similarity between language groups and the uniformity

across speakers of the same group are striking. The only deviation worth mentioning is that of one male Galician speaker whose realization is more fronted and is heard as an apical, Spectral Mean = 4068 Hz (with values between 2776 and 5553 Hz). The differences between front and postalveolar fricatives are always statistically significant.

In Table 3, on the other hand, we observe a substantial difference between the spectral means of Galician and Portuguese front sibilants. Consequently, the distance between the values for /s/ and /ʃ/-type sibilants is considerably smaller in Galician (with 1813 Hz for women, 1458 for men, averaged across all speakers) than in Portuguese (3050 for women, 3622 for men).

4.3. Alveolar and alveolo-dental sibilants

Distinguishing between front sibilants using spectra and spectral means is challenging, mainly owing to high variability not only between languages but also between speakers of the same language. This variability was pointed out in various earlier studies (e.g. Dart 1998, Gordon et al. 2002, Andrade and Slifka 2005). With regard to Galician speakers, both Labraña (2009, 2014) and Regueira (2014) found it difficult to distinguish types of /s/ because of the high level of variation among individuals and even among realizations by the same individual. This variability is an obstacle to statistical calculations and needs to be borne in mind when interpreting the results.

The findings of the present study confirm this variability, which is much greater among the Galician informants, whereas Portuguese speakers exhibit more similar behaviour across speakers.

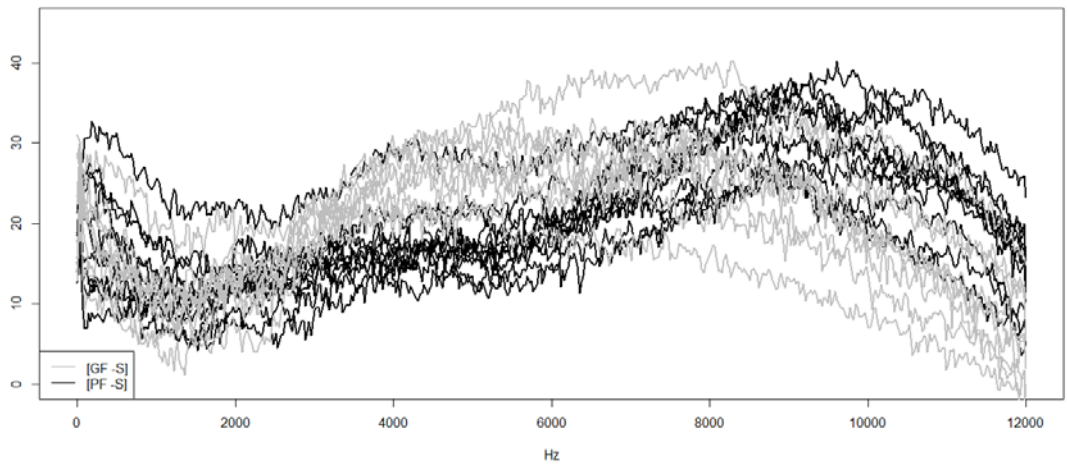

Figure 1: Average spectra for front sibilants (S) in female Galician (GF, grey) and Portuguese (PF, black) speakers.

Figure 1 shows average spectra for front sibilants for female Galician and Portuguese informants. For Portuguese speakers the spectrum rises to a maximum peak above 8 kHz (spectral mean 7782 Hz), while the spectra for Galician speakers form an arc that tends to reach its spectral maximum around 6 kHz (spectral mean 5960 Hz).

The spectra for male Portuguese speakers have similar profiles to those for female speakers, with spectral peaks higher than 8 kHz, although slightly lower than those of female speakers. The results for Portuguese spectral mean (means of 7782 Hz for women, 7196 Hz for men) are consistent with Silva's (2012) findings for Brazilian Portuguese.

Male Galician informants show more varied behaviour in which we may identify three spectrum types, based on maximum peaks and centres of gravity (see Figure 2):

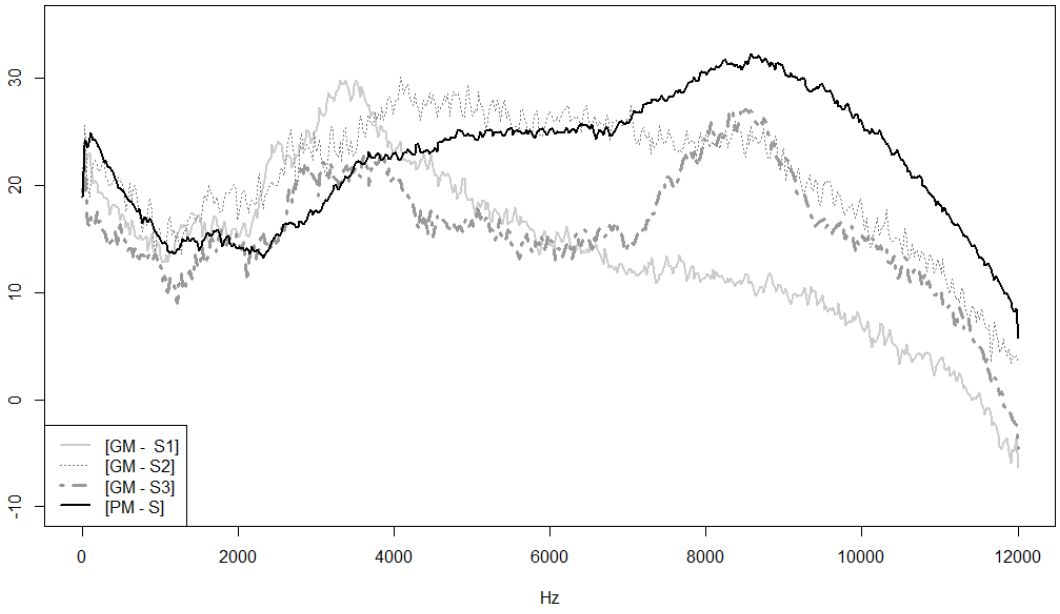

Figure 2: Average of the three spectrum types for male Galician speakers: S1 (average of 4 speakers), S2 (average of 2 speakers), S3 (average of 2 speakers), compared with male Portuguese [s] (PM-S).

As we can see in Figure 2, the first group (S1) is characterised by a prominent peak in relatively low frequencies (between 2500 and 5000 Hz, averaging 3328 Hz), and a profile showing some similarity to that of [ʃ] (see Figure 5). The S2 type presents no narrow band peaks but a presence of high energy between 4 and 7 kHz (the average highest peak is 5104 Hz). Type S3, on the contrary, is characterised by two peaks, one

of which, almost always the main one, is over 8 kHz (average 8314 Hz), and a secondary peak between 3 and 4 kHz (averaging 3536 Hz).

Table 4: Spectral mean, kurtosis and skewness for Galician male groups S1, S2 and S3

Groups Galician	Spectral Mean (Hz)	Std Dev (Hz)	Kurtosis	Skewness
S1 GM	3482	515	0.452	0.067
S2 GM	5353	1025	-0.556	-0.310
S3 GM	6266	1054	-0.183	-0.382

Taking into account spectral mean, kurtosis and skewness (see Table 4), we find that the three groups are statistically different. Since the analysis of variance (ANOVA) hypotheses were not confirmed for one factor, the Kruskal-Wallis non-parametric test showed significant differences in the averages for each group (p-value < 0.01) [spectral mean: chi-squared = 112.2588, df = 2, p-value < 2.2e-16; N= 170; n1= 76, n2=41; n3 = 53; Kurtosis: 76.4784, df = 2, p-value < 2.2e-16; N= 170; n1= 76, n2=41; n3 = 53; Skewness: chi-squared = 86.5484, df = 2, p-value < 2.2e-16; N= 170; n1= 76, n2=41; n3 = 53].

The TukeyHSD test (post-hoc analysis), which was carried out to reveal whether the three groups are mutually distinct, yielded the result that these are three separate groups for all three measures (spectral mean, kurtosis and skewness) because the different p-values after adjustment for the multiple comparisons were less than 0.01.

Articulatory identification of these three groups is difficult because of the scarcity of acoustic analyses dealing with the issue and because the mechanisms for fricative production and the effect of different articulatory variables (constriction length, sublingual cavity, etc.) are poorly understood. A comparison of available data for Spanish and Portuguese may be useful here.

Andrade and Slifka (2005) analyse two female speakers' realizations of lamino-dental and apico-dental sibilants. The lamino-dentals present a similar spectral profile to that which we have found for our Portuguese informants (and type S3 male Galician speakers), but the apico-alveolars present two different patterns, one that is closer to the lamino-dentals and another that is more similar to the profile for [ʃ], as in type S1 (Figure 2). The authors conclude that the constriction commonly described as apico-alveolar may be more fronted in speakers of the dialect they are examining and that

acoustic characteristics which make it possible to differentiate apical and laminal articulations are due to the contribution of the sublingual cavity. Toda, Maeda and Honda (2010) study the formant-cavity affiliation for Polish alveolo-palatal [ɕ] and apico-postalveolar fricatives (this latter transcribed here by [s̺], see footnote 2, p. 372) using MRI and acoustic data, and they conclude that the front oral cavity, larger for the latter sibilant, is responsible for the lower frequency of its first fricative formant (p. 369), but they do not attribute a significant role to the sublingual cavity *per se*.

As for Spanish, Martínez Celdrán and Fernández Planas (2007: 110-111) say that in the apical sibilant the first peak is the one with the greatest intensity and is situated at relatively low frequencies (4622 Hz), whereas in the laminal the most prominent peak is the second one, situated at 6230 Hz.

Labraña (2009: 206) identifies the S3 spectral type with the lamino-dental fricative [s̪], and the S1 and S2 types with apicals, and attributes the differences mainly to the influence of the context. However, our data, supported by the references mentioned in the preceding paragraph, have led us to question that identification. For one thing, the S2 type spectrum is the one that appears in Galician areas with lamino-alveolar *seseo* (Regueira 2014), which is where some of our informants come from. Indeed, this is the profile of all our female Galician informants, among whom we did not find any instances of an S1 type spectrum (see Figure 1), even among speakers who are expected to pronounce [s̪]. The realizations of some of these female speakers are acoustically very similar to "laminal *seseo*." When asked, later, about the articulatory gesture they carried out when producing the sibilant, some described a laminal gesture while others said they placed the tip of their tongue in the alveolodental region, supporting Andrade and Slifka's (2005) conclusion.

When we compare the average spectra of four women from areas with [s] to those of four others from areas that apparently have [s̪], the spectra are almost identical (see Figure 3).

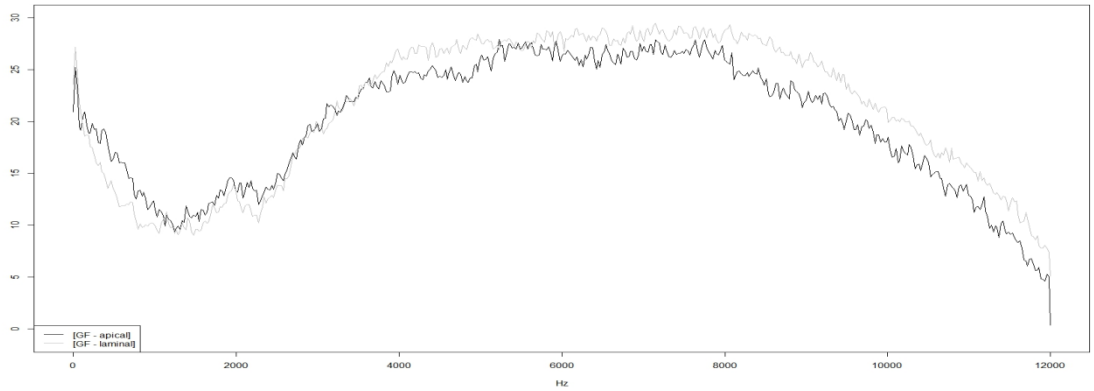

Figure 3: Average spectra of the front sibilant of female Galician informants from the laminal [s] area and the apical [s̻] area.

The spectral means for both groups are also very similar (laminal group 6000 Hz, St. Dev. 1516 / apical group 5.872 Hz, St. Dev. 1244). Student's *t*-test shows the two samples to be statistically equal: t = t= 0.704, p=0.48, df = 512, N=513. This seems to mean that the existing articulatory descriptions are not accurate and there has probably been a change in course in the realization of these sibilants, with regard to the type 1 models, present in several of the male informants. This type of spectra has not been observed among Portuguese informants, which with some variation all follow the profiles shown in Figures 1 and 2.

4.4. Final sibilants

The articulatory descriptions of Galician and Portuguese sibilants show a clear-cut difference in that Portuguese final sibilants are considered to be realized as the lamino-postalveolar [ʃ] (Mateus and d'Andrade 2000: 11-12), while in Galician an apico-alveolar [s̻] is usually assumed, even in areas with lamino-alveolar *seseo* (i.e. [s] in onset); in some cases in these areas it alternates with an apico-postalveolar [s̺] realization, which is acoustically very similar to the Portuguese realization (González 1991, Regueira 2013).

For Portuguese speakers, our findings support the descriptions: the final sibilant in both men and women has a less intense spectrum, but with the same shape as syllable-initial [ʃ] (see Figure 4).

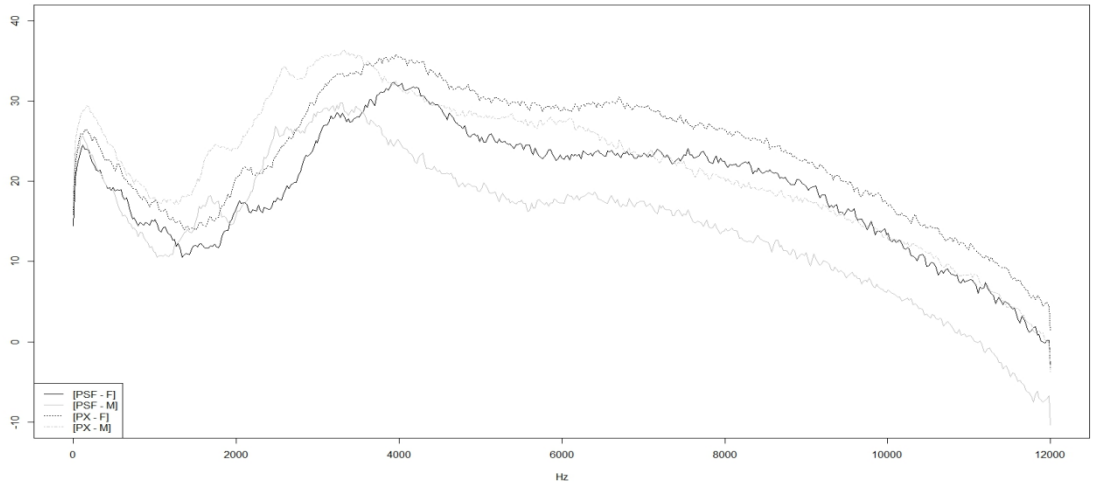

Figure 4: Average final sibilant (PSF) and syllable-initial [ʃ] (PX) spectra in realizations by Portuguese speakers (male and female groups).

Male speakers' spectral means are a little lower for [ʃ] in onset: PM 3296 Hz in coda, as compared to 3611 Hz; PF 4458 in coda, as compared to 4469 Hz in onset.

Only two male informants with the lamino-dental sibilant [s̪], out of all the Galician informants, have a similar pattern (see Figure 5), with a sibilant that we can identify as a lamino-postalveolar fricative [s̪]. The two speakers' spectral means are 2788 and 2796 Hz respectively, which agrees with the values which Zeller (2011: 117) considers to be those of this sibilant.

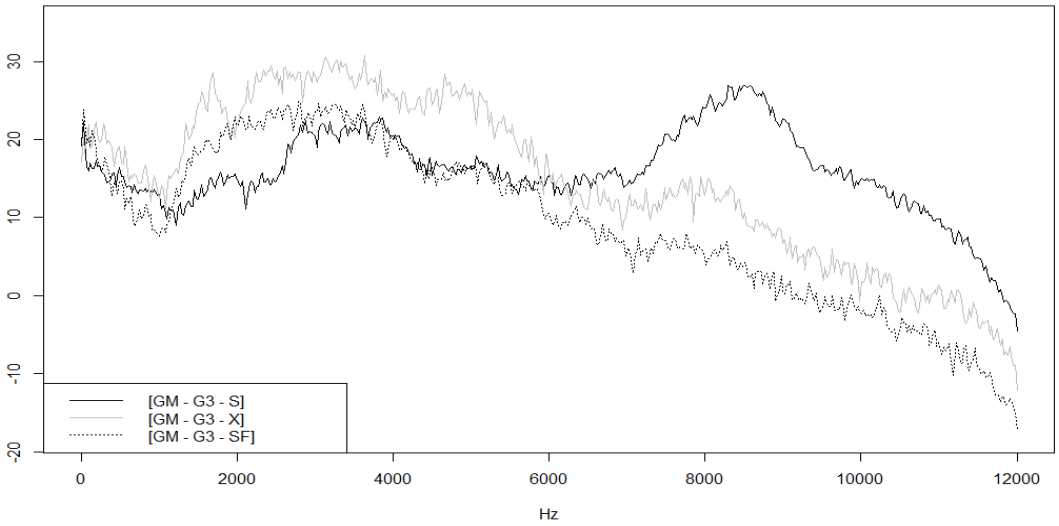

Figure 5: Average spectra of the sibilant in coda position (GM-G3-SF), [ʃ] (GM-G3-X) and [s̪] (GM-G3-S) in Galician speakers with lamino-dental *seseo*.

However, when we compare the sibilant in coda position of female informants with the average spectra of the two fricatives (see Figure 6), we notice that the spectral shape of the final sibilant resembles that of [s] in onset position, although it presents a lower spectral mean (5166 Hz in coda, 5941 Hz in onset, as compared to 4124 for [ʃ]).

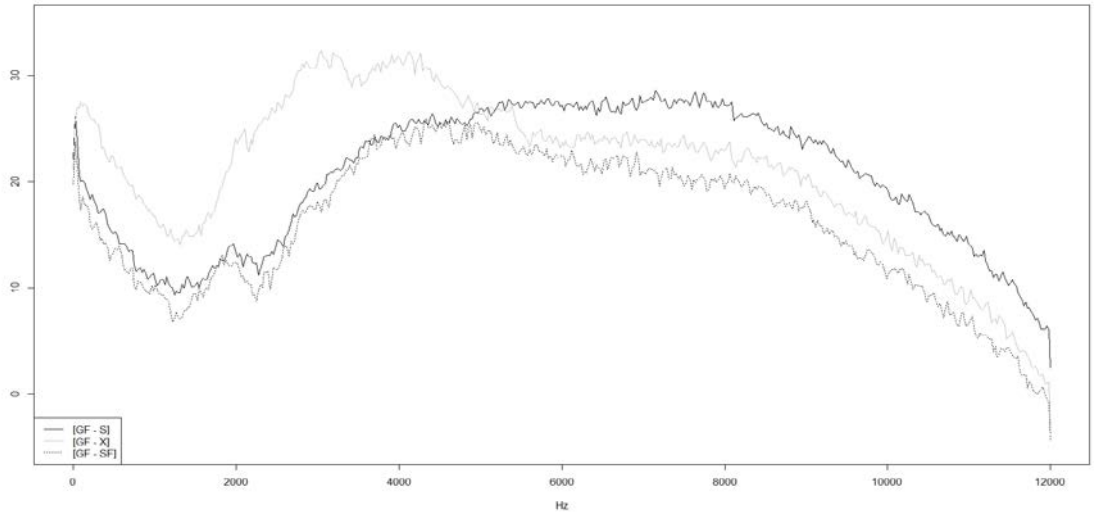

Figure 6: Average spectra for realizations of word-final sibilant (GF-SF), [ʃ] (GF-X) and [s] (GF-S) in female Galician speakers.

Tables 5 and 6 show correlations of the spectral mean of the fricatives [s], [ʃ] and the sibilant in final position (SF), by sex, in Galician and Portuguese informants respectively. The relevant correlations (those over 0.7) are shown in grey.

Table 5: Correlations between fricatives for spectral mean in Galician speakers by sex.

Galicia							
	Women			Men			
Spectral mean	s	ʃ	SF	Spectral mean	s	ʃ	SF
s	1	0.625	0.872	s	1.000	0.569	0.090
ʃ	0.625	1	0.45	ʃ	0.569	1	0.315
SF	0.872	0.447	1	SF	0.090	0.315	1

Table 6: Correlations between fricatives for spectral mean in Portuguese speakers by sex.

Portugal							
	Women			Men			
Spectral mean	s	ʃ	SF	Spectral mean	s	ʃ	SF
s	1	-0.063	0.002	s	1	0.467	0.498
ʃ	-0.063	1	0.891	ʃ	0.467	1	0.738
SF	0.002	0.891	1	SF	0.498	0.738	1

For Portuguese (Table 6) there are strong correlations between [ʃ] and SF for both sexes. On the other hand, in Table 5 we see that for Galician women the final sibilant correlates strongly with [s]. In male informants there are no clear correlations given the heterogeneity of realizations in word-final position. The different groups for S1, S2 and S3 among Galician men are too small (4, 2 and 2 speakers) to present significant correlations. However, the strongest correlation of the final sibilant is with [s], since most speakers produce an apico-alveolar sibilant [s̪].

5. Conclusions

The analysis of spectra and spectral moments, chiefly the spectral mean, has allowed us to differentiate efficiently between postalveolar sibilants /ʃ/ and front (alveolar or alveolo-dental) sibilants in both Galician and Portuguese. In line with previous studies, we encountered a great deal of variation in the realization of alveolar consonants between speakers and also in different realizations by the same speaker, which in some cases can be an obstacle for statistical treatment of the data.

Variation is most notable in the Galician sample, particularly among males, where we can distinguish three different groups. We suggest that these correspond to three realizations of the front sibilant: apico-alveolar [s̪], lamino-alveolar [s] and lamino-dental [s̪]. However, further study is necessary to confirm this hypothesis, because the S2-type spectra could arise from different articulatory gestures, one of which is a more fronted apical articulation, in contrast to the S1 type which is a more back apical. In other words, we cannot be sure that the acoustic differences reflect exclusively differences in the place of articulation, or follow from a different shape and length of

constriction (Andrade and Slifka 2005). Instrumental articulatory studies are needed in order to achieve a more precise characterization of the articulatory gestures responsible for the observed acoustic differences.

The Portuguese realizations present a more uniform picture where, even though there is some significant variation, the consonants are in all cases lamino-dental or, at the most, a very fronted lamino-alveolar.

The greater uniformity of the Portuguese samples as compared to the Galician ones may reflect greater linguistic uniformity among Portuguese university-educated young people, whereas the more varied and heterogeneous Galician sample reflects the much more limited levelling achieved by standard Galician, which has spread through Galician society much more recently and far less completely.

In all events, the data suggest that the pronunciation of sibilants in Galician is more complex than most descriptions indicate and that the apico-alveolar type is not the only way they are pronounced in varieties of Galician without *seseo* (i.e. with an opposition between /θ/ and /s̪/). The standard descriptions of Portuguese also seem imprecise on this point.

Finally, the type of Galician that most resembles Portuguese (with lamino-dental realizations and post-alveolar final sibilants) does not occur in any of the university-educated speakers. It may be that this absence is due to the small size of the sample, but our experience suggests that speakers who come from those areas avoid such pronunciations, which are considered dialectal and rural. The pronunciations in question are on their way out, and they are avoided when speaking in public and interacting with people who are not members of one's own speech community. No instances occurred of alveolar pronunciations of sibilants in Portuguese. Thus the data point to the fact that language change on both sides of the border are having the effect of reducing diversity and increasing the distance between Galician and Portuguese.

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