An Articulatory Study of Sibilant Fricatives in Two Spanish Varieties

Laura Colantoni and Alexei Kochetov
University of Toronto

1. Introduction

In spite of the attention that Spanish sibilants have received in diachronic and synchronic variationist studies, very little is known about cross-dialectal differences in the articulation of these consonants. For example, although the degree of coda /s/ weakening is widely known to vary across dialects, it is generally assumed that onset /s/ is articulated in the same way in all the varieties that have either a laminal or an apical realization. Less is known about the realization of other sibilants, such as [ʃ], that are absent in some Spanish varieties and differ in their phonemic affiliation in others. As illustrated in (1a), in Cuban Spanish, the post-alveolar fricative is the preferred realization of the affricate in intervocalic position which contrasts with the alveolar fricative. On the other hand, in Argentine Spanish the post-alveolar fricative is a separate phoneme that contrasts both with the post-alveolar affricate and the alveolar fricative (1b).

(1) a. Cuban Spanish: [ʃ] (/tʃ/) vs. /s/
[koʃe]~[kotʃe] *coche* 'car' [kose] *cose*, 's/he sews'

b. Argentine Spanish: /ʃ~ʒ/ vs. /tʃ/ vs. /s/
[aʃe]~[aʒe] *halle*, 's/he finds SUBJ.' [atʃe] *hache*, 'aitch'
[ase] *hace*, 's/he makes'.

Given that articulatory studies on fricatives and affricates in other Romance varieties (e.g. Catalan: Recasens & Espinosa 2007) have consistently shown cross-dialectal differences, and that phonological and phonetic theories (e.g. Adaptive Dispersion Theory: Lindblom 1983) would predict different realizations for each dialect, we set forth to compare the articulatory characteristics [s] and [ʃ] in Argentine and Cuban Spanish via the use of electropalatography (EPG). In particular, we predict that the articulatory differences in the realization of sibilant fricatives should be greater in Argentine Spanish, where there is a three-way phonemic contract, than in Cuban Spanish, where there are two sibilant phonemes.

2. Articulatory and acoustic characteristics of Spanish sibilant fricatives

Up to the present, there is only one comprehensive articulatory study of Spanish consonants (Fernández Planas 2001, 2007). Her electropalatographic study includes data gathered from four Peninsular speakers from different parts in Spain. Given that /ʃ/ is absent from the Peninsular inventory, only the information regarding /s/ and /tʃ/ is relevant for the present study. Results of Fernández Planas' work showed that for all four speakers, /s/ is an apical alveolar with a narrow central opening. The degree of contact is slightly higher in the second than in the first row of the artificial palate (cf. Martínez Celdrán & Fernández Planas 2007:100). /s/ significantly differs in place from /t/, which is the most fronted coronal in Peninsular Spanish, after /θ/. The affricate is classified as alveolo-palatal; it does not differ from /t/ in the degree of contact anteriority in the closure phase, but the affricate release shows extensive posterior and side contact.

Although no other EPG studies are available for Spanish, results obtained for Catalan are relevant for the present study for several reasons. First, Catalan and Spanish are closely related languages.

Second, unlike Peninsular Spanish, Catalan has post-alveolar fricatives, and thus, we can compare them against the post-alveolar fricatives in the two varieties under investigation. Second, recent cross-dialectal studies (Recasens & Espinosa 2006, 2007) have shown systematic articulatory differences between Catalan varieties, and thus, we should not be surprised to find similar differences across Spanish varieties. Overall, Recasens and colleagues have shown that Catalan /s/ closely resembles its Peninsular Spanish counterpart. As in Spanish, the Catalan /tʃ/ is classified as alveolo-palatal. The closure exhibits contact in rows 3-5 of the artificial palate and the release shows extensive lateral contact. Comparisons of Valencian and Majorcan Catalan did show that varieties differ in the articulatory (and acoustic) distance between anterior and posterior sibilants. Posterior sibilants are more fronted in Valencian and exhibit less dorso-palatal contact. As a result, the contrast between anterior and posterior sibilants is reduced in Valencian vis-à-vis Majorcan Catalan. This was also the case for affricates, which are more anterior in Valencian than in Majorcan.

Although the focus of this paper is on the articulatory properties of sibilants, acoustic studies are a crucial point of departure for the characterization of less-studied varieties, such as Argentine and Cuban Spanish. Acoustic studies on Argentine Spanish (Borzone de Manrique & Massone 1981; Santagada & Gurlekian 1989) demonstrated that post-alveolar fricatives differ from /s/ in their noise spectrum; the spectral peak is higher in the latter (~5,000Hz) than in the former (~2,500Hz). Post-alveolar fricatives in Argentine Spanish also differ in their degree of voicing (Chang 2008), and voiced and voiceless variants appear to be sociolinguistically stratified (Wolf & Jiménez 1979; Wolf 1984). Acoustic studies have also reported variability in the realization of affricates in Caribbean Spanish. In particular, Quilis (1993) observed 6 different realizations in Puerto Rican Spanish. These realizations included the standard affricate, affricates with very short occlusions and fricative realizations varying in length and intensity fricative noise.

3. The study

3.1. Research questions

This study is part of a more general investigation of coronal consonants in the Argentine and Cuban varieties of Spanish (Kochetov & Colantoni, in press). As mentioned above, the main goal of the current study is to compare the realization of sibilant fricatives in two varieties that differ in the phonemic affiliation of [ʃ] and in the number of fricative and affricate phonemes. Argentine Spanish displays a 3-way contrast among an alveolar fricative, a post-alveolar fricative and an alveolo-palatal affricate. In Cuban Spanish, on the other hand, there is no phonemic post-alveolar fricative; this is an allophone of the affricate that, in our corpus, is found mostly in intervocalic position (Kochetov & Colantoni, in press). A secondary goal of this study is to speculate about the implications of our findings for theories of speech production.

Four research questions guide the present study:

Q1: Do sibilants fricatives differ in place between dialects?

Q2: Do sibilants fricatives differ in the amount of linguo-palatal contact between dialects?

Q3: Is the same active articulator involved in the production of fricatives in both dialects?

Q4: Do dialects differ in the degree of articulatory separation between sibilant fricatives?

3.2. Participants

Five Argentine (A1-A5) and three Cuban speakers (C1-C3) participated in the study. With the exception of A5, all participants were female. In order to minimize sociolinguistic variation, speakers were all born and raised in Buenos Aires or Havana, respectively; they all had university education, ranged in age between 23-49; and, at the time of testing, they all lived in Toronto, Canada. Participants have lived outside their own countries for 2-6 years, with the exception of A3, who has lived outside Argentina for 10 years. All participants traveled to their home-countries frequently and reported to use Spanish on a daily basis. Participants had no history of speech or hearing impairment problems.

An artificial EPG palate with 62 electrodes was custom-made for each of the participants. Before each recording session, participants underwent a desensitization period during which they were asked to read a text and to have an extended conversation with one of the authors. The recording began when the participants were judged by the first author, a native speaker of Spanish, to have normal undistorted speech.

3.3. Materials

Target words included stimuli with word-initial affricates (*chata*, ‘flat’), alveolar fricatives (*saga*, ‘saga’ and *zanja*, ‘hole’) and orthographic <ll,y> (*llave*, ‘key’ and *yale*, brand name), which are realized as post-alveolar fricatives in Buenos Aires Spanish but as approximants in Cuban Spanish (at least intervocalically). All words, which were controlled for stress and vowel context (following [a]), were embedded in the same carrier sentence: *Diga* _______ *otra vez*, ‘say ______again’.

3.4. Instrumentation and procedure

Simultaneous articulatory and acoustic data were collected using a WinEPG system by *Articulate Instruments* (Wrench et al. 2002). Articulatory data were sampled at 100 Hz, while acoustic data were sampled at 22,050 Hz. Recording took place at the Linguistics Phonetics Lab at the University of Toronto. The recordings were done in two separate sessions, with 6 repetitions of each sentence elicited per session. For C2 and C3 only one session was held. As a result, 12 repetitions of each of the target words were recorded for six participants (A1-A5; C1), and 6 for remaining two participants (C2-C3), leading to a total of 420 tokens (A1-A5; C1: 5x6x12=360; C2-C3: 5x2x6=60).

3.5. Data analysis

The *Articulate Assistant* software (http://www.articulateinstruments.com/) was used for data collection, segmentation, annotation, and analysis. For all target fricatives, the onset and offset of the constriction was determined by analyzing the onset and offset of the fricative noise in the acoustic signal. For affricates, the closure was taken to be an interval between the first frame of a complete articulatory closure (shown on the EPG display as a row with all the electrodes on) and the onset of fricative noise; the frication was based on the onset and offset of fricative noise. For each constriction, we further identified the midpoint and the point of maximum contact (PMC) – the frame with the highest number of ‘on’ electrodes. If more than one such frame occurred, we selected the one closer to the midpoint. Measurements of the tongue-palate contact were made at PMC for all consonants, except affricate releases, which were measured at the frication midpoint[1] (cf. Recasens & Espinosa 2006). Extracted PMC data were converted to several articulatory indices described below (following Fontdevila et al. 1994). Note that R_1-R_8 represent 8 rows and C_1-C_8 represent 8 columns of the EPG palate. All palates have the same number of rows and columns, and the same number of electrodes in each row and column. Row 1 has 6 as opposed to 8 electrodes, and this is also the case of columns 1 and 8. The rows of the palate are conventionally assigned to different places of articulation – front alveolar, post-alveolar, and palatal.

- Contact Anteriority in the alveolar region (CAa): the frontmost position of the constriction in the first 5 rows, with higher values corresponding to a more anterior constriction.
  $$CAa5=(\log((1*(R_5/8)+9*(R_4/8)+81*(R_3/8)+729*(R_2/8)+4921*(R_1/6))+1))/(\log(5741+1))$$
- Contact Centrality for the alveolar region (CCa): the degree of central occlusion in the 5 central columns of the first 5 rows, with higher values corresponding to a greater central occlusion.
  $$CCa5 = [\log[[1((C_1+C_8)/8)+11((C_2+C_7)/10)+121((C_3+C_6)/10)+1331((C_4+C_5)/10))+1]]/[\log(1464+1)]$$
- Quotient of activation for the palatal region (Qp): the amount of contact in the last 3 rows,

[1] The midpoint was found to be more representative of the frication, as its PMC tended to correspond to the first, highly constricted palate after the closure.

with higher values corresponding to sounds with greater palatal constriction.

$Qp3 = [(R_6 + R_7 + R8)/24]$

Articulatory analysis of target consonants was supplemented by their informal acoustic inspection. In order to test between-dialect differences, statistical analyses based on articulatory indices were performed using repeated measures ANOVAs. The within-subject factor was Consonant with two levels ([s] vs. [ʃ]); the between-subject factor was Dialect also with two levels (Argentine and Cuban). Additional one-way ANOVA's were calculated to test differences between the two sibilant fricatives within dialects.

4. Results

4.1. Articulatory characteristics of the target consonants

In this first section we present the overall articulatory characteristics of each of the target consonants by variety. Starting with [s], mean linguo-palatal contact profiles displayed in Figure 1 illustrate some of the differences between dialects.

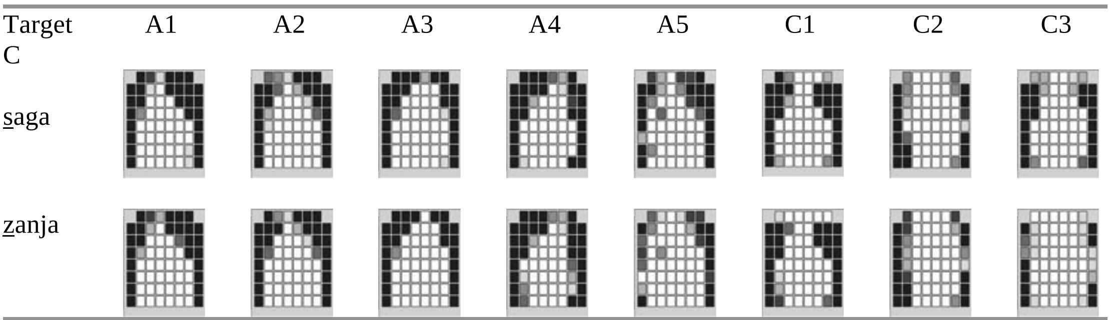

Figure 1: Individual linguo-palatal contact profiles for [s], averaged over six repetitions of each word. The different shades of grey represent different degrees of contact (black=100%; white=0%)

The first difference in the articulation of [s] relates to place: this fricative is more fronted in Argentine than in Cuban Spanish. Indeed, in the former variety the constriction is located in rows 1-3 of the artificial palate, while in Cuban Spanish the constriction is located further back. The second difference concerns the degree of opening of the central channel; whereas in Argentine Spanish this channel is rather narrow (i.e. one cell in row 1), in Cuban Spanish /s/ is articulated with a wide central opening, ranging from 2 to 4 cells.

Figure 2 displays the realization of orthographic <ll, y>. As expected, clear cross-dialectal differences are observed. In Cuban Spanish, this consonant is realized intervocalically as a palatal approximant, as shown by the highest degree of activation of the electrodes in the palatal region.

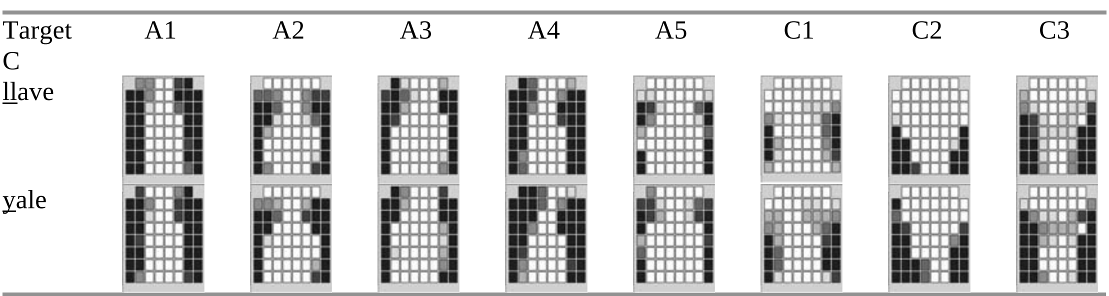

Figure 2: Individual linguo-palatal contact profiles for [ʃ]~[ʒ] (A1-A5) and [j̞] (C1-C3), averaged over six repetitions of each word. The different shades of grey represent different degrees of contact (black=100%; white=0%)

One of the speakers (C2) articulates this consonant with a narrow central constriction, while for the other two participants the central channel is wider and the side contact extends further front. However, given that all three Cuban speakers articulate this consonant as a palatal fricative or approximant, as described in previous literature (e.g. Hualde 2005), we will not focus on its realization in the present study. In Argentine Spanish, on the other hand, <ll, y> are realized as a post-alveolar fricative, with a constriction variably located (see §4.3 below) in the first five rows of the palate and considerable side contact. The central channel is wider than the one observed for [s], but as in the case of place, it displays some inter-speaker variability.

Finally, Figure 3 illustrates the realization of <ch> in both varieties. The five Argentine participants realize this consonant as an affricate with a clear alveolar occlusion that may variable extend from rows 1 to 4. The release displays similar characteristics to the fricatives in Figure 2, although with a generally wider central constriction. Given the consistent affricate realization in this group, this consonant will not be further studied here.

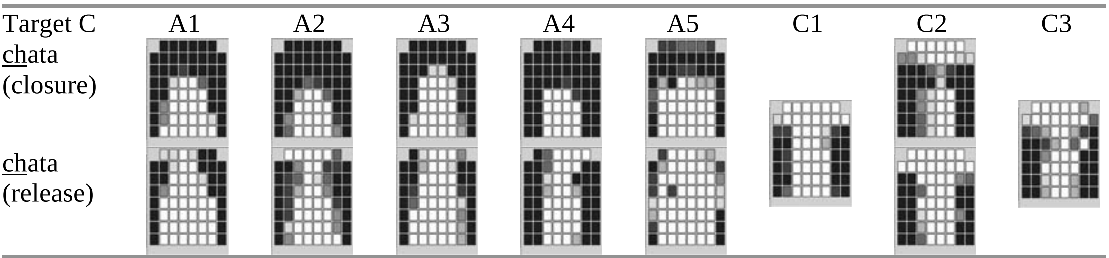

Figure 3: Individual linguo-palatal contact profiles for /tʃ/, averaged over six repetitions of each word. The different shades of grey represent different degrees of contact (black=100%; white=0%)

Interestingly, the Cuban speakers show two clear patterns: C1 and C3 produce this consonant without a closure. Thus, the underlying affricate is realized as a fricative with a relatively wide central channel (especially in the case of C1) and extensive side contact. A first comparison of the realization of this fricative and the one produced by Argentine speakers and displayed in Figure 2 indicates that the consonants appear to be more similar in the degree of contact than in place; indeed the Cuban [ʃ] is articulated further back. The third Cuban participant produces an affricate with an incomplete closure. If we compare the closure to the one produced by the Argentine speakers, we conclude that not only it is incomplete but it is also articulated further back (no contact in the first row and only partial contact in the second row). The release, on the other hand, closely resembles the consonant produced by the other two participants.

In summary, given the realizations for underlying /s/, /tʃ/ and /ʝ/ or /ʃ/ described so far, we will center our comparison on, first, the realization of [s] in both dialects. Second, the realization of the phoneme /ʃ/ in Argentine Spanish will be compared to the fricative variant of the affricate /tʃ/ in Cuban Spanish. As such, the affricates in Argentine Spanish, the realization of the words ‘llave, yale’ by Cuban speakers as well as the realization of the affricate by C2 will not be subject to further analysis in the present study.

4.2. Cross-dialectal and within dialect comparison

We will start our cross-dialectal comparison by analyzing the realization of [s] in both dialects. Given that [s] is an alveolar fricative, differences will be explored in the front area of the artificial palate. As such, we will compare the values of two indices: Contact Anteriority and Contact Centrality in the alveolar region (CAa and CCa: see §3.5). Recall that the former is an index of place that indicates how anterior or posterior the contact is (values closer to 1 signal a more anterior articulation), whereas the latter is an index of central constriction degree that signals how narrow or wide the central channel is in the front part of the palate (values closer to 1 indicate a more constricted articulation). Figure 4 displays the values obtained for these indices for [s] in both dialects, revealing some unexpected cross-dialectal differences in the articulation of the consonant. Indeed this fricative is both more anterior and more constricted for the Argentine speakers than for the Cuban speakers.

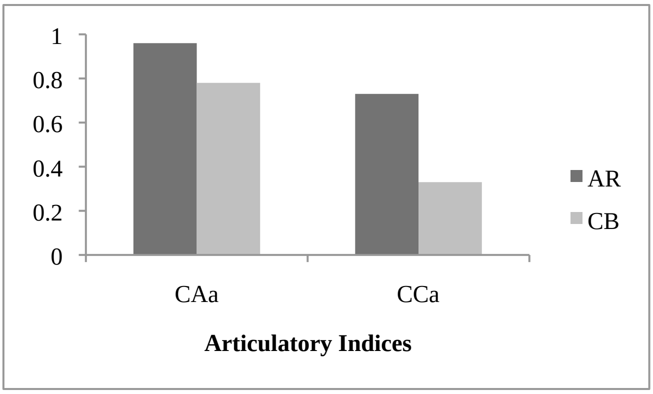

Figure 4: Mean CAa and CCa values for [s] in Argentine (AR) and Cuban (CB) Spanish

Figure 5 displays the results obtained for the other sibilant fricative studied here; i.e. [ʃ]. As opposed to [s], we are comparing here an additional index, the Quotient of activation for the palatal region, given that it may be the case that cross-dialectal differences are not only present in the location and degree of contact in the anterior area but also in the palatal area.

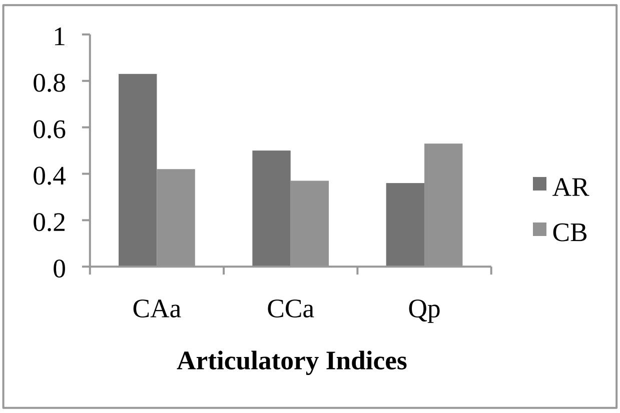

Figure 5: Mean CAa, CCa and Qp values for [ʃ] in Argentine (AR) and Cuban (CB) Spanish.

As in the case of [s], [ʃ] is articulated further front (CAa) and displays a higher degree of central constriction in the anterior area (CCa) in Argentine than in Cuban Spanish. On the other hand, this sibilant fricative shows a higher degree of constriction in the palatal area in Cuban than in Argentine Spanish.[2] A Repeated Measures ANOVA with within-speaker factor Fricative ([s] and [ʃ]) and a between-speaker factor Dialect (Argentine and Cuban) revealed a significant effect of Fricative for CAa ($F(1,5) = 22.214$; $p<.006$), Qp ($F(1,5) = 19.088$; $p<.008$), but not for CCa ($F(1,5) = 1.575$; $p=.265$). There was also a significant effect of Dialect for CAa ($F(1,5) = 41.947$; $p<.002$) and CCa ($F(1,5) = 7.784$; $p<.04$), but not for Qp ($F(1,5) = 2.853$; $p=.152$). There was a significant interaction of Fricative and Dialect for CCa ($F(1,5) = 6.922$; $p<.05$), indicating that cross-dialectal differences for constriction degree in the alveolar area (CCa) applied to [s] but not to [ʃ]. There were no other significant interactions. Statistical results, although indicative of consistent cross-dialectal differences, should be

[2] The higher degree of contact in Cuban Spanish vis-à-vis Argentine Spanish could also be attributed to the fact that our Cuban participants had, on average less concave palates than the Argentine participants (see Kochetov & Colantoni, in press).

interpreted with caution, given the differences in the number of tokens in each sample, especially in the case of [ʃ].[3]

Thus, results reported so far revealed consistent cross-dialectal differences in the degree of fronting of both sibilant fricatives and in their constriction degree. Both fricatives are significantly more fronted and more constricted in Argentine Spanish.

Now, in order to determine how different these consonants are by dialect, we set forth to compare the articulation of [s] and [ʃ] within each dialect. If phonemic affiliation plays a role in determining the degree of articulatory separation between these consonants, we would expect to see a larger difference in Argentine than in Cuban Spanish, given that in Argentine Spanish we have a three-way sibilant contrast, whereas in Cuban Spanish there are only two sibilant phonemes. Figure 6 combines the results obtained for the four articulatory indices for both sibilant fricatives.

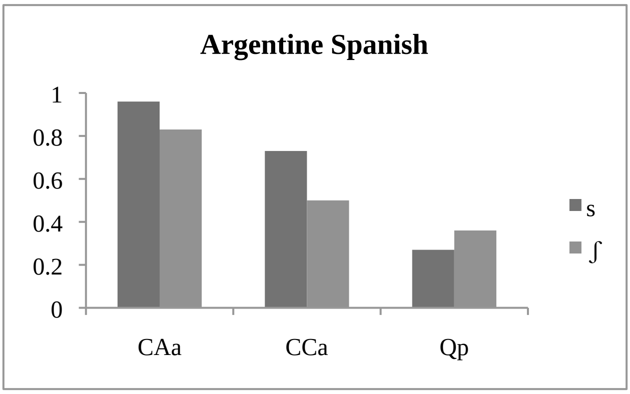

Figure 6: Mean CAa, CCa and Qp values for [s] and [ʃ] in Argentine Spanish

Figure 6 shows that [s] and [ʃ] in Argentine Spanish differ in the degree of anteriority (CAa), in contact centrality (CCa), and in the overall degree of contact in the palatal area (Qp). Results of a one-way ANOVA indicate that differences were highly significant for these three parameters (CAa: $F(1,238)=202.74$; $p<.0001$; CCa: $F(1,238)=154.97$; $p<.000$; Qp: $F(1,238)=49.55$; $p<.000$). This confirms that [s] differs from [ʃ] in being more anterior and more constricted in the anterior area, whereas [ʃ] displays a higher degree of contact in the palatal area. Similar comparisons for Cuban Spanish (Figure 7) revealed that, as expected, [s] is more fronted than [ʃ] but the differences in place between this pair of consonants is larger in Cuban than in Argentine Spanish.

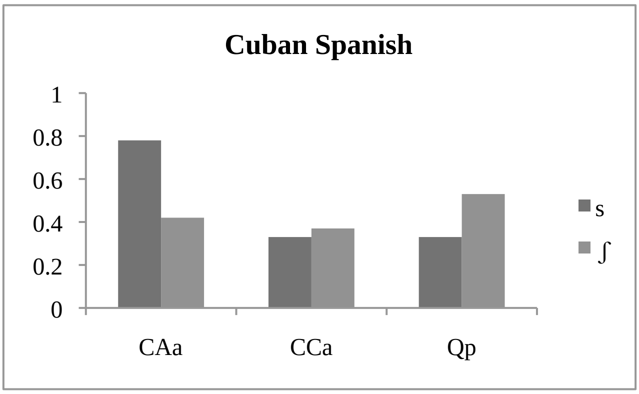

Figure 7: Mean CAa, CCa and Qp values for [s] and [ʃ] in Cuban Spanish

[3] We remind the reader that, given the variation in the Cuban group, we are comparing data from 5 Argentine speakers against 2 Cuban speakers.

As in Argentine Spanish, the two fricatives significantly differ in the degree of anteriority (CAa: $F(1,64)=62.37$; $p<.0001$) and in the quotient of palatal activation (Qp), which was significantly higher for [ʃ] than for [s] ($F(1,64)=88.9$; $p<.0001$). As opposed to Argentine Spanish, the two fricatives do not significantly differ in the degree of central constriction (CCa: $F(1,64)=1.38$; p=n.s.).

In summary, within-dialect comparisons yielded significant differences in the articulation of both sibilant fricatives. In Argentine Spanish, both consonants significantly differed in all indices analyzed here, with the differences being smaller in CCa. In Cuban Spanish, large significant differences were found in the degree of anteriority and in the quotient of palatal activation. Differences were not significant, though, in CCa, showing that both consonants are articulated with a central constriction of a similar size.

4.3. Inter-speaker variability

In the results reported so far, we have compared first (§4.1) the overall patterns of linguopalatal contact and the mean differences for the four relevant articulatory indices (§4.2). In order to have a better picture of how these sibilant fricatives are articulated in each dialect and to determine whether there might be a potential merger between them, it is important to assess the degree of within category variability for each group and for each of the speakers in each group. Given that the main differences between both fricatives appeared to be in CAa and CCa, we will focus our analysis on the results obtained for each of these two indices. Figure 8 displays the degree of variability of CAa in each dialect separately. As can be seen, [s] not only is more anterior in Argentine Spanish but it is also less variable.

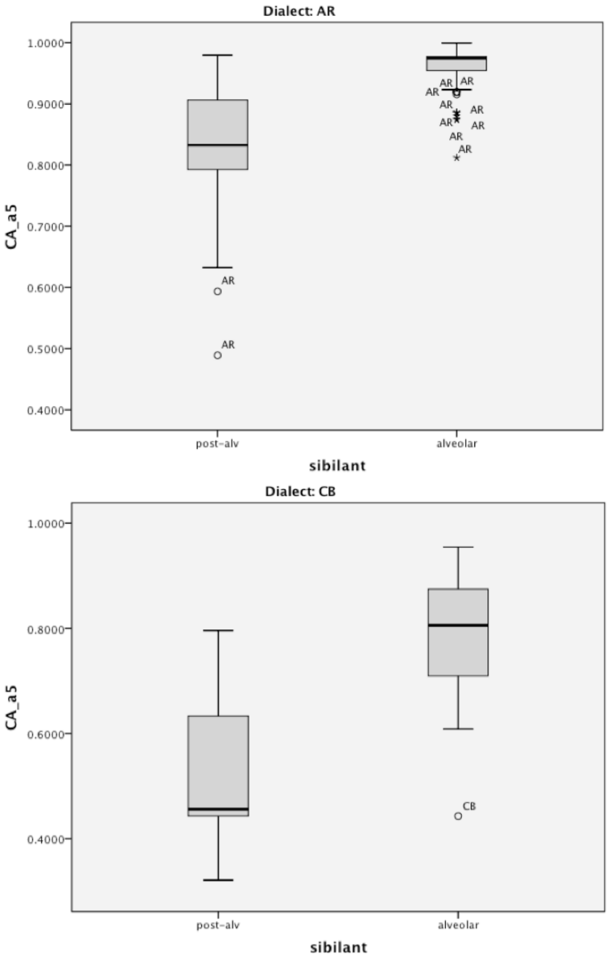

Figure 8: CAa values for each sibilant by dialect; Argentine Spanish (top) and Cuban Spanish (bottom)

This overall tendency for CAa is also valid for each of the individual speakers. As seen in Figures 9 & 10, the Argentine speakers have a clearly fronted [s] with the probable exception of A5, the only male participant, who has a slightly more retracted articulation. A5, indeed, is the only Argentine participant that shows some overlap between the CAa values obtained for [s] and for [ʃ]. Moreover, some of his [s] realizations displayed some overlap with the upper values obtained for the Cuban participants. The mean values for each of the Cuban participants are clearly below the mean for all the Argentine speakers, but participants differ in the degree of fronting and in the degree of within category variability as well; C2 has the most fronted and least variable realization, followed by C1 and C3, respectively.

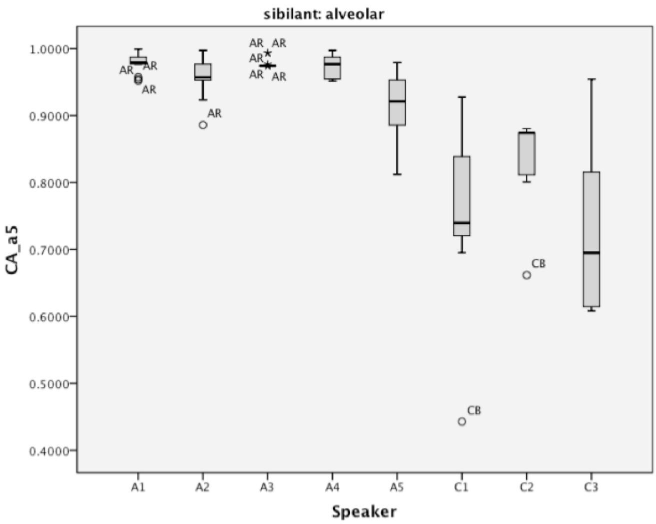

Figure 9: Box plot of CAa values for [s] by speaker (A1-A5: Argentine Spanish; C1-C3: Cuban Spanish)

Individual variability in place is clearly larger for the post-alveolar fricative, especially within the Argentine group (variance=.009). This group differs from the Cuban group not only in the degree of fronting but also in the degree of within-category variability, which is larger in the latter (variance=.020).

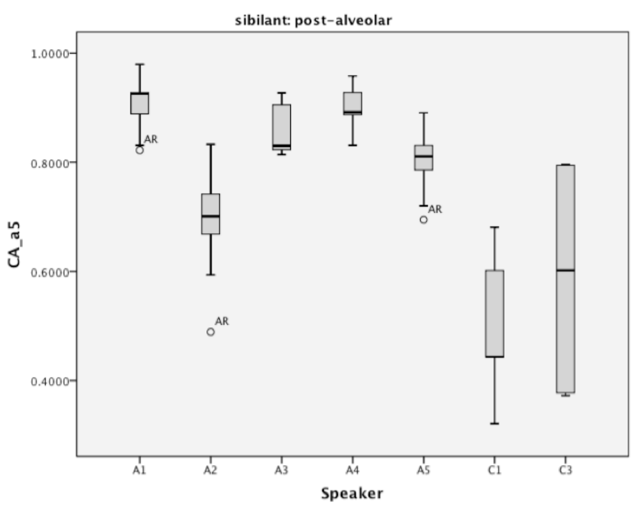

Figure 10: Box plot of CAa values for [ʃ] by speaker (A1-A5: Argentine Spanish; C1 & C3: Cuban Spanish)

Results for the degree of linguopalatal central contact in the alveolar area (CCa) resemble those for CAa. Figure 11 displays group results for each fricative. Once again, in Argentine Spanish, the alveolar fricative shows a higher degree of linguopalatal contact and is less variable than the post-alveolar fricative. In Cuban Spanish, both sibilants not only are extremely similar in the degree of contact, as mentioned in §4.2 but they also display a similar variance ([s]=0.27; [ʃ]=0.33). One interesting difference, however, is that, in the box-plot corresponding to the post-alveolar sibilant fricative, the whisker only extends above the upper-quartile, suggesting that there are more tokens with high CCa than with low CCa values.

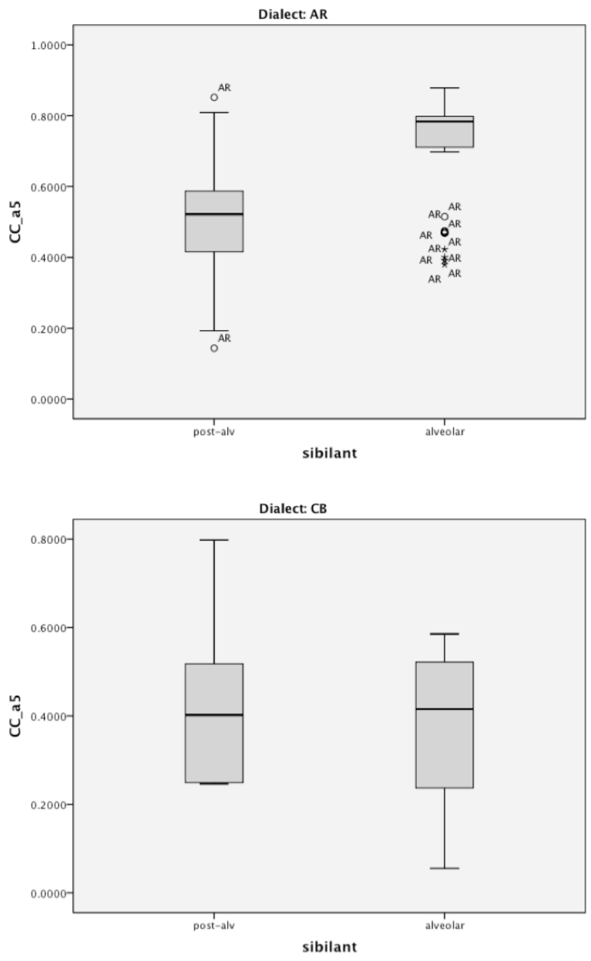

Figure 11: CCa values for each sibilant by dialect; Argentine Spanish (top) and Cuban Spanish (bottom)

Individual results for [s] for Argentine speakers (Figure 12) reveal again an interesting difference between the four female speakers (A1-A4) and the only male speaker who participated in the study. Whereas the female speakers produced a more constricted and less variable alveolar fricative (variance range: .001-.006), the male speaker's realizations showed less central alveolar constriction and more variability (variance=.027). Inter-speaker variability is also observed in the Cuban group. In this case, we can clearly see that C1 differs from the other two Cuban participants in the degree of central alveolar constriction, as indicated by the higher CCa values obtained. Indeed, this speaker may be responsible for the lack of significant differences in CCa between [s] and [ʃ] reported in the previous section.

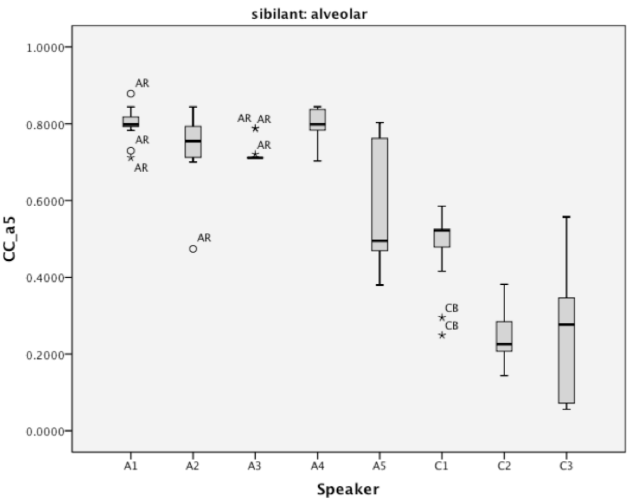

Figure 12: Box plot of CCa values for [s] by speaker (A1-A5: Argentine Spanish; C1-C3: Cuban Spanish)

Values for CCa obtained for the post-alveolar fricative (Figure 13) showed the greatest degree of inter- and within speaker variability (Variance: A1-A5=0.11-0.18; C1-C3=0.27-0.34). In the Argentine group, A5, who showed the least fronted realizations, also displayed the lowest CCa values. It would be possible to think that low CCa values are the result of a more posterior constriction, but a quick inspection of Figure 2 reveals that this is not the case. When compared to the other speakers in the group, the palates of A5 showed a wide central channel with no clear constriction either in the front or in the back of the palate. Instead, these differences could be attributed to the fact that A5 categorically produced a voiceless variant. These differences could also be attributed to gender factors, which is something that deserves further exploration. The two Cuban speakers also displayed a high degree of within category variability, but as opposed to the Argentine participants, the two speakers differ greatly in the mean CCa values, with C1 displaying a less constricted articulation in the anterior area.

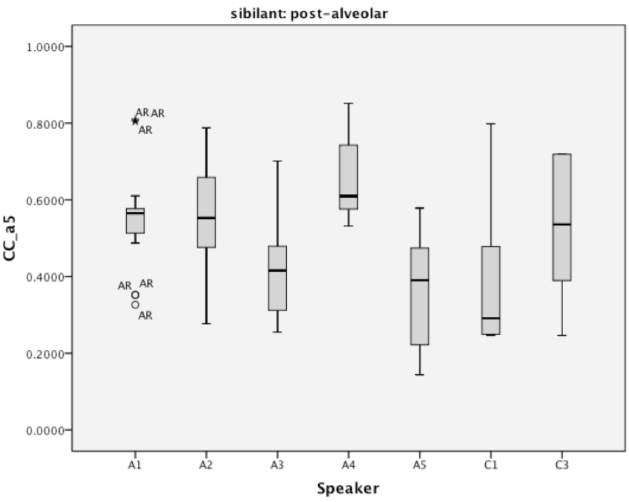

Figure 13: Box plot of CCa values for [ʃ] by speaker (A1-A5: Argentine Spanish; C1 & C3: Cuban Spanish)

In summary, the analysis of between and within group variability for each of the consonants under study revealed, first, interesting cross-dialectal patterns. The alveolar sibilant fricative is more fronted and less variable in Argentine Spanish both in place and in the degree of constriction. Dialects also differ more in place (CAa) than in the degree of the linguo-palatal contact for the post-alveolar sibilant fricative. Second, different degrees of within and inter-speaker variability were found within each dialectal group. In the Argentine group, the largest differences are observed in CCa, in particular in the values obtained for [ʃ]. A higher degree of within and between-speaker variability was obtained for Cuban Spanish. This is particularly the case both in the degree of fronting and of linguo-palatal contact of [ʃ].

5. Discussion

5.1. Cross-dialectal differences in place and manner

Of the four questions that this study attempted to answer, three had to do with the articulatory characteristics of target fricatives in Argentine and Cuban Spanish. In particular, we wanted to find out if the different phonemic affiliation of the post-alveolar fricative (a phoneme in Argentine Spanish but a variant of /tʃ/ in Cuban Spanish) had any impact on its articulation. Thus, our first question had to do with potential differences in place. As we have seen, not only the post-alveolar but also the alveolar fricative significantly differed in place across dialects. Both sibilant fricatives in Argentine Spanish are significantly more fronted in this variety vis-à-vis Cuban Spanish. This is a surprising finding. Although it is well-known that Spanish dialects differ in the weakening patterns of coda /s/, no study so far has reported differences in place for onset /s/ in Latin American varieties (we are referring here to varieties with laminal /s/), neither have they reported differences for the post-alveolar fricative.

Second, we explored differences in manner, in particular in the degree of linguo-palatal contact across dialects. Once again, significant differences emerged. Both consonants are significantly more constricted in Argentine than in Cuban Spanish. This is particularly the case in the articulation of the alveolar sibilant fricative, which is clearly more constricted and displays less within-category variability in Argentine than in Cuban Spanish.

Our third question had to do with the active articulator involved in the production of our two target consonants. Although EPG does not capture directly differences in the involvement of the active articulator, it allows us to make indirect inferences by studying the contact patterns in the artificial palate. Concerning the articulation of /s/, there appear to be cross-dialectal differences in the role of the active articulator. Argentine participants articulated this consonant with extensive contact in the first three rows, suggesting an apico-laminal articulation, whereas this consonant seems to be laminal for most of the Cuban speakers, with the probable exception of C1, who variably produced an apico-laminal fricative. More within group variation is observed in the articulation of /ʃ/ in the Argentine group. Three speakers (A1, A3, A4) produced an apico-laminal fricative, whereas the consonant appears to be mostly laminal for the other two speakers (no contact in the first two rows) as well as for the Cuban participants.

In summary, our study revealed systematic and previously unreported differences in the articulation of two sibilant fricatives in two Spanish varieties. This is particularly surprising for /s/, which, when compared to Peninsular Spanish (Fernández Planas 2007) and to other Romance varieties (Recasens & Espinosa 2007), is more fronted in Latin American varieties. Moreover, there are clear place differences in varieties, such as Argentine and Cuban, that have been described as having the same type of /s/. Differences also were apparent for the post-alveolar fricative; thus the phonemic consonant and the one resulting from deaffrication of /tʃ/ systematically differ in place and degree of linguo-palatal consonant. Interestingly, the consonant produced by two of our Cuban participants resembles more closely the Catalan (cf. Recasens & Pallarès 2001) than the Argentine /ʃ/. More importantly, the findings of our study - the first cross-dialectal articulatory comparison of two Spanish varieties – go in line with those reported for Valencian and Majorcan Catalan (Recasens & Espinosa 2007). As in the case of Valencian, in Argentine Spanish the two sibilant fricatives studied here are systematically more fronted than the Cuban counterparts.

5.2. Variability and inventory size

The question now is what the sources of these systematic differences are. The first apparent answer is that differences may be due to the inventory size. Indeed, the anterior coronal space is more "crowded" in Argentine than in Cuban Spanish, given that the historic merger between /ʎ/ and /ʝ/ (orthographic <ll, y>) resulted in a post-alveolar fricative in Buenos Aires Spanish (i.e. /ʃ/ or /ʒ/), and palatal approximant/fricative /ʝ/ in Cuban Spanish. If differences were related to the inventory size, we would predict more dispersion/separation between sounds in Argentine than Cuban Spanish (e.g. Diehl & Lindblom 2000; Boersma & Hamman 2008) and probably more variability in Cuban than in Argentine Spanish. In terms of the articulatory separation between the two target consonants, which was the fourth question of this study, we conclude that in both varieties the two consonants are significantly distinct in place, in particular in the degree of fronting, albeit these differences are larger in Cuban Spanish. Differences, however, were not significant in the degree of constriction in Cuban Spanish, but, as we mentioned, we had a high degree of inter-speaker variability and fewer participants in the Cuban group. Variability in the four articulatory indices studied here also appears to be larger again in the Cuban than in the Argentine group. Once again, however, caution is needed given the differences in the samples. Thus, on the one hand, our results seem to support the hypothesis that contrast and inventory size play a role in the phonetic distance between segments, providing partial evidence against acoustic studies that found no differences in the characteristic of sibilant fricatives in languages that differed in the phonemic affiliation of the target consonants (cf. Evers et al. 1998).

However, the cross-dialectal differences that we found are more in line with the findings of other articulatory studies on Romance varieties (e.g. Recasens & Espinosa 2007), where systematic differences in the articulation of fricatives and affricates were found in varieties that had the same phonemic inventory. As such, results suggest that differences between varieties have more to do with the dialect-specific degree of fronting of coronal consonants and the overall degree of constriction in the articulation than with the presence or absence of additional phonemes in the inventory.

5.3. Implications for theories of speech production

We conclude our discussion by analyzing the indirect and direct implications of our findings for theories of speech production. As we mentioned in the previous section, our findings have indirect implications for theories of speech production such as Dispersion theory (Liljencrants & Lindblom 1972) and its revised version the Theory of Adaptive Dispersion (Diehl & Lindblom 2000). In short, the theory of Adaptive Dispersion claims that the minimization of perceptual confusion is the force driving the organization of phonemic inventories. Our results showed that in the variety where there is a three-way contrast, and crucially where the post-alveolar is phonemic, the alveolar and post-alveolar fricatives differed significantly in all the articulatory indices that we analyzed. For the most part, this was also the case in the other variety, with the aforementioned exception of the lack of differences in the degree of central constriction in the alveolar region (CCa). Thus, both varieties maintain an articulatory distance between the two fricatives, at least in what concerns the place of articulation; and, indeed this distance appears to be even larger in Cuban Spanish where the post-alveolar sibilant fricative is not phonemic. The claims of Dispersion Theory, however, are based on acoustic data, and it could perfectly be the case that the articulatory distances in place that we observe are not perceptually significant.

On the other hand, if our results are put in the context of the whole coronal inventory for each variety (see Kochetov & Colantoni, in press) and the findings of the few existing cross-dialectal articulatory studies mentioned above, we believe that they are more consistent with the claims by the Articulatory Settings Theory (Honikman 1969). This theory predicts that the articulatory properties of the whole phonemic inventory of a given language/variety are derived from the specific articulatory settings of the most frequent consonants in the language. As in many other languages, coronals are the most frequent consonants in Spanish (e.g. Quilis 1993). If the most frequent coronals, i.e. /s/, are more fronted in a given variety, then we can expect that the other coronals, including the post-alveolar, sibilant fricative also be more fronted. And this is what we observed in the two varieties studied here.

6. Conclusion

This study compared the articulatory characteristics of [s] and [ʃ] in two Spanish varieties (Argentine and Cuban) that differ in the phonemic affiliation of the latter sound; in Argentine Spanish, [ʃ] is a separate phoneme, whereas in Cuban Spanish is an allophone of /tʃ/. Our results surprisingly revealed systematic cross-dialectal differences in the articulation of both sounds. Both fricatives are more fronted and more constricted in Argentine than in Cuban Spanish. In addition, our results showed that the phonemic post-alveolar and the one resulting from deaffrication present consistent articulatory differences in place, degree of constriction, and for some speakers, in the role of the active articulator. Thus, given that systematic and parallel differences were found both in sounds with the same and different phonemic affiliation, we believe that our results can be interpreted in the frame of the Articulatory Settings Theory (Honikman 1969), namely that the systematic dialectal difference are not the result of local contrast but of the articulatory characteristics/settings that define the whole consonantal inventory.

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