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## SOCIOPHONETICS AND FRICATIVES

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### **Introduction**

The present chapter has two main aims: first, to provide a broad overview of the sociophonetic research related to fricatives across languages and, second, to home in on a specific fricative process: the voicing of intervocalic /s/. Intervocalic /s/ voicing in Spanish (e.g., *masa* ‘dough’ as [‘ma.za]) is considered nonstandard, yet it occurs across several distinct dialects. Some of these dialects coexist with other languages, such as Quechua and Catalan, and this language contact appears to influence the voicing process in Spanish (Davidson 2019a, 2020, 2021). In other regions, however, this process cannot be readily attributed to language contact and appears to be an endogenous phenomenon, as is the case in San José, Costa Rica (Chappell & García 2017) and Loja, Ecuador (García 2020).

Although social and linguistic variables have been found to condition intervocalic /s/ voicing somewhat differently across the Spanish-speaking world, speaker gender has consistently been identified as a significant factor. The case study provided in this chapter explores the ways in which sociolinguistic factors, with a special focus on gender, condition /s/ voicing across three dialects of Spanish—namely those spoken in Barcelona, San José, and Loja. Using percent voicing of intervocalic /s/ in conversational Spanish as our acoustic measurement across three datasets, our comparative analysis sheds light on how a single social factor can come to influence one phonetic variable across varieties of the same language. To set the stage, we first offer a broad sketch of previous sociophonetic research on fricatives. We then present our case study before offering concluding thoughts and suggesting future directions for sociophonetic research on fricatives.

### **Literature review**

#### ***Previous sociophonetic research on fricatives***

This section summarizes some of the most prominent methods, theories, research questions, and findings to have emerged in sociophonetic research on fricatives. Numerous fricative processes associated with social groups and/or social meanings take place across the world’s languages, and this brief section aims to provide a broad overview of the most thoroughly researched of these

processes. Beginning with the acoustic measurements employed in previous research on fricatives, this section then explores some of the key debates revolving around fricatives in English, Spanish, and other languages.

Acoustic measurements are a useful tool for objectively classifying fricatives, as, for example, different places of articulation are associated with high amplitudes within specific frequency ranges. A power spectrum is generally used to capture how fricatives' acoustic energy is distributed along one or more of the four spectral moments (see Shadle & Mair 1996; Jongman, Wayland & Wong 2000; van Son & van Santen 2005). Among the measurements typically extracted from a Long Term Average Spectrum (LTAS), center of gravity (COG) is the most common in sociophonetic work on fricatives, providing a weighted average of the frequencies in the spectrum (Thomas 2016). COG is also referred to as the first spectral moment, spectral mean, or centroid (Kendall & Fridland 2021:63). The other moments include measurements of spectral variance (also known as the second spectral moment, range, or spread), which determine the range of energy concentration; skewness (the third spectral moment), which establishes how symmetrically distributed the energy is within the spectrum; and kurtosis (the fourth spectral moment), which identifies the propensity for outliers in the acoustic energy's distribution (see Gradoville, Brown & File-Muriel 2022). Some studies utilize all four spectral moments (e.g., Jannedy et al. 2010), while others use fewer moments.

Across studies, different combinations of moments have been selected for analysis. For example, Stuart-Smith (2007) incorporates COG and standard deviation in her analysis of /s/ in Glaswegian. Other scholars employ less common acoustic measurements, such as the overall intensity within the spectrum (e.g., Minnick Fox 2006), the spectral peak frequency (e.g., Jongman, Wayland & Wong 2000), the zero crossing rate (e.g., Nance & Stuart-Smith 2013; Ruch & Harrington 2014), the intensity of the third formant (e.g., Jongman, Wayland & Wong 2000), the amplitude ratio between the second formant and most prominent peak (e.g., Li, Edwards & Beckman 2007), measurements of vowel formants during transitions (Thomas 2011:104, 115), measurements of psychoacoustic spectra like peak  $ERB_N$  number (Reidy 2016), and spectral slope measures along with the dynamic range of the spectrum (Jesus & Shadle 2002).

While the vast majority of fricative research incorporates static acoustic measurements (i.e., measures either pulled from a specific point in time during a fricative's production or averaged across the fricative's duration), dynamic measures capturing time-varying change from the start to the end of the fricative's production have also been successfully integrated in sociophonetics. For example, Stuart-Smith (2020) applied Discrete Cosine Transformation (DCT) to obtain continuous trajectory shapes of both COG and spectral slope for /s/ in Glasgow English and Reidy (2016) used polynomial growth-curve analysis to differentiate spectral peak trajectories between English and Japanese fricatives.

Jesus & Shadle (2002) additionally incorporate measurements of devoicing in their work on European Portuguese fricatives, and, similarly, percent voicing is often used to classify fricatives in Spanish (Rohena-Madrado 2015; Chappell & García 2017; Davidson 2020; García 2020). An ongoing debate in the measurement of percent voicing has been whether to treat voicing as a continuous measurement (e.g., Schmidt & Willis 2011), to partition percent voicing into categories like unvoiced/voiceless, partially voiced, and fully voiced (e.g., Campos-Astorkiza 2014), or both (e.g., Hualde & Prieto 2014). Some studies utilize Praat's voicing report (e.g., Hualde & Prieto 2014; Rohena-Madrado 2015), while others (e.g., Campos-Astorkiza 2014; Strycharczuk et al. 2014) measure percent voicing "by hand," judging which portion of the fricative is voiced based on the waveform/spectrogram, as the voicing report can be fooled by "phantom glottal pulses" that do not correspond with voicing (Gradoville 2011:70).

Central to the debate about how to operationalize percent voicing is how much voicing is necessary for a fricative to be perceived as voiced, which has been investigated in perception studies that examine the categorization of fricatives in synthesized or manipulated stimuli. An effect of fricative duration on the perception of voicing is found in English (Cole & Cooper 1975) and Spanish (Widdison 1997), whereby longer fricatives are more likely to be perceived as voiceless. Overwhelmingly, though, the studies that manipulate multiple acoustic characteristics reveal a stronger effect of voicing duration/ratio on the perception of voicing than fricative duration, vowel duration, or VC formant transitions across languages, including English (Jongman 1989; Stevens et al. 1992; Smith 2013), Portuguese (Pape et al. 2015), and Hungarian (Bárkányi & Kiss 2021).

For place of articulation, Jongman (1989) demonstrates that fricative duration influences perception of place in English fricatives, while Mann & Soli (1991) argue that vocalic cues also affect the perception of English [s] versus [ʃ]. Other studies have compared the use of perceptual cues among speakers of different languages. For instance, Broersma (2010) finds that, when determining final fricative voicing in English stimuli, Dutch listeners use preceding vowel duration less than English listeners, showing that the perceptual cues they use in Dutch in intervocalic context are not transferred to the L2 (English) word-final context. Finally, Blecua Falgueras & Rost Bagudanch (2015) used naturally occurring variants of intervocalic /f/ in a perception experiment to establish how different realizations ([f], [ɸ], [v], and [β]) are categorized phonologically, concluding that [v] can be interpreted as both /f/ and /b/. As a whole, these studies demonstrate the complexity inherent in the perception of fricatives and point to the need to consider the interconnectedness of multiple perceptual cues as listeners process and categorize auditory stimuli.

Of course, sociophonetic research on fricatives goes a step beyond acoustic analysis and phonological perception, introducing social variables with the goal of assessing how acoustic differences distinguish social groups and/or individuals. As acoustic measures reflect articulatory gesturing and positioning, acoustic data can be carefully interpreted with respect to unique articulatory configurations, and thus may also reflect physiological differences between (groups of) speakers. Acoustic measures can also be used to determine correlations between articulatory configurations and the social stratification or ideological meaning of specific features. One such feature is tongue position, for which there exists considerable variation both at inter- and intra-speaker levels. Variability in the degree of more backed or more fronted tongue position is strongly correlated with acoustic measurements such as COG and spectral peak frequency, such that higher values signal more fronted tongue positioning, whereas lower values signal more backed tongue positioning. In English and other languages, tongue positioning has been rather robustly linked to unique gender groups, with women producing /s/ as more fronted than men (Stuart-Smith 2007; Levon & Holmes-Elliott 2013; Podesva & Van Hofwegen 2014; Podesva & Van Hofwegen 2016). This gender stratification in production has in turn led to ideological associations between tongue position and femininity/masculinity, such that listeners readily associate more fronted /s/ productions as more feminine, and more backed /s/ productions as more masculine (Campbell-Kibler 2011; Mack & Munson 2012; Levon 2014; Pharo et al. 2014; Zimman 2017; Calder 2019). The combination of production and perceptual patterning of tongue position for /s/ production accordingly facilitates the treatment of /s/ as a highly gendered sociophonetic variable.

Acoustic measurements have also proven useful in analyses of Spanish /s/ weakening (e.g., *pasta* ‘paste’ realized as [ˈpah.ta]), a phenomenon that has been linked with a range of social meanings. Although the phenomenon has generally been explored auditorily, with listener judgments defining the boundaries of the traditional variants [s], [h], and ø (e.g., Cedergren 1973), Erker (2010), and File-Muriel & Brown (2011) suggest that instrumental measures (such as /s/

duration, COG, and voicelessness) are superior to categorical representations, accounting for more variance and more accurately reflecting nuanced patterns in the data. However, Brogan & Bolyanatz (2018) contend that instrumental measurements alone may obscure the social distribution and behavior of the variants. They find an ordinal approach to weakening that combines perceived variants and instrumental measures better captures the meaningful social distinctions in their data, simultaneously acknowledging the gradience inherent to lenition processes while also taking into account the psychological importance of the segment to speakers/listeners. Several studies have shown that the variants of /s/ evoke social meanings specific to the local communities in which they live, and a purely instrumental analysis may overlook the social significance of these ordinal categories to the population under investigation. For Mexican and Puerto Rican listeners, for example, the aspirated variant is associated with lower status and, for most listeners, greater heteronormativity, but these evaluations are filtered through regional stereotypes and listener expectations (Walker et al. 2014; Chappell 2019). Local norms can even influence the perception of the prestige variant; in Uruguay, where the “standard” [s] is negatively associated with border Spanish influenced by Portuguese, the “nonstandard” [h] is used as a marker of social prestige to evoke the cultural capital of Montevideo and the variety of Spanish spoken there (Carvalho 2006).

A range of social meanings linked to fricatives that are specific to the local context have been identified across languages, including work on interdental fricatives in Cajun and Newfoundland English (Dubois & Horvath 1998; Childs et al. 2010), h-dropping in Essex English (Cole 2020), /θ/-fronting in northern and southern British English (Schleef & Ramsammy 2013; Levon & Fox 2014), the deaffrication of /tʃ/ in the Spanish of Chile and Huelva, Spain (Regan 2020b; Boomershine & Forgash 2021), rhotic assimilation and the bilabial fricative in Mexican Spanish (Rissel 1989; Robles-Puente & Vilches-Aguado 2019), and the loss of distinction between [ʃ] and [ç] in German (Jannedy & Weirich 2014). For example, Jannedy & Weirich’s (2014) perception study demonstrated that listeners associate a particular merger in German (/f/ and the [ç] allophone of /x/) with the Turkish German population. Although scholars have drawn on different theoretical frameworks to account for the relationship between social and linguistic factors, many recent sociophonetic studies, including those exploring fricative phenomena, have called upon indexicality to make sense of phonetic variants’ social meanings (e.g., Chappell 2016). Phonetic variants that develop social meaning become signs, and the creation of a sign in turn creates orders of indexicality (Silverstein 2003), which can be thought of as points along a line of social meaning. The first order indexes a group of people, the second takes on a meaning related to this group, and the reconstrual of social meanings continues linearly in the third, fourth, fifth order, and so on, progressively taking on related social meanings. Indexical fields help capture the perpetual reconstrual of social meaning by displaying the range of possible “ideologically related meanings, any one of which can be activated in the situated use of the variable” (Eckert 2008:454).

Social meaning plays such a crucial role in linguistic variation and change that the behavior of certain fricatives seems to upend established linguistic theory. For instance, using demerger indices created for each speaker using COG, mean intensity, skewness, and variance, Regan (2020a) investigated the demerger of /s/ and /θ/ in Huelva and Lepe, Spain. Although Garde’s Principle states that innovations can result in mergers but cannot demerge them (Garde 1961:38–39, as cited in Labov 1994:311–313) and, similarly, Herzog’s Principle explains that “mergers expand at the expense of distinctions” (Herzog 1965, as cited in Labov 1994:313), Regan (2020a) demonstrates that under certain circumstances, such as large-scale societal changes and greater dialectal contact, /s/ and /θ/ can demerge. As a prestigious change from above, the demerger is being led by certain social groups like women, more educated individuals, younger speakers, and professionals with service-related positions.

Another widespread Spanish merger, that of /k/ and /j/, has given rise to two salient and well-studied fricative processes in Argentinian and Uruguayan Spanish: *zheísmo* and *sheísmo*. Following the merger (e.g., *malla* ‘mesh’ and *maya* ‘Maya’ both became /maja/), the palatal fricative /j/ was strengthened to [ʒ] (*zheísmo*) and, in some regions like Buenos Aires, devoiced (*sheísmo*). The extent of this change in progress in Buenos Aires has been debated over the years; early studies found that devoicing was led by the lower and middle classes (Fontanella de Weinberg 1978), and more recently, Chang (2008) proposed the sound change had been completed among speakers born after 1975, who nearly categorically produced the voiceless variant across social groups. If the sound change had been completed, Rohena-Madrado (2015) posited, the devoiced [ʃ] in Buenos Aires should behave like the voiceless /s/ in Spanish, which undergoes gradient voicing due to co-articulation. Using percent voicing to explore allophonic patterns, the comparison showed that only young, middle-class speakers produce similar voicing patterns for both fricatives, which suggests the change is complete only for this group, while other speakers continue to voice the prepalatal fricative more than /s/. This devoicing process serves as an excellent case study to evaluate different metrics of fricative voicing, which is taken up by Gradoville (2011) in his comparison of instrumental techniques and analysis of which technique best matches up with auditory coding of [ʃ] and [ʒ]. Examining fricative duration, percent voicing, harmonicity, relative intensity, and COG, Gradoville concludes that percent voicing is one of the most reliable measurements of fricative voicing.

Why the fortition of /j/ and its subsequent devoicing has taken place in River Plate Spanish and not in other varieties harkens back to the actuation problem (Weinreich, Labov & Herzog 1968). An attempt to solve the problem has centered around fricatives in recent years, namely work on /s/ retraction (e.g., *street* becomes more like [ʃtɹi:t]), which takes place across several varieties of English. In their work on American English, Baker, Archangeli & Mielke (2011) argue that the presence of interspeaker phonetic variation in a particular community (i.e., retractors and non-retractors) facilitates listener perception of a phonetically motivated co-articulatory phenomenon as a new production target, which can then spread socially throughout the community. However, Harrington et al.’s (2018) interactive-phonetic model, when applied to Stevens & Harrington’s (2016) /s/-backing data from Australian English, contrasts with the notion that variants spread socially through a community due to preferential accommodation (Giles, Taylor & Bourhis 1973). Rather, they contend that stable phonetic biases can be converted into sound changes through more general speech properties as a result of individuals in contact with each other, a process that is more automatic in nature than social.

In addition to highlighting several different methods applied to the investigation of fricatives across languages, the studies outlined in this section have drawn attention to important ongoing debates, namely, the origination of phonetic change and the constraints that condition its social diffusion. Through this very brief literature review, we have seen that the complexities of fricative phenomena allow for a rich investigation of the interaction between social and linguistic forces.

### *Homing in on intervocalic /s/ voicing in Spanish*

Though Spanish /s/ is most often investigated with respect to its possible aspiration or elision (Chappell 2016:361), its voicing constitutes another rich source of sociophonetic variation. Spanish voiceless alveolar [s] and voiced alveolar [z] are prescriptively found in complementary distribution for the lone alveolar fricative phoneme /s/, with [z] being restricted to contexts of a following voiced (semi)consonant (e.g., *desde* ‘since/from,’ *isla* ‘island,’ *los huecos* ‘the holes,’ *las hierbas* ‘the herbs’) as a product of regressive voicing assimilation (Hualde 2014:154–155).



In the remaining contexts, including intervocalic position, Spanish /s/ is systematically realized as [s] (e.g., *sopa* ‘soup,’ *casa* ‘house,’ *pasta* ‘pasta,’ *comes* ‘you eat’), with [z] being described as “abnormal and sporadic” (Navarro Tomás 1918:83 [authors’ translation]). Nevertheless, empirical research on Spanish /s/ across several varieties (e.g., Peninsular Spanish [Campos-Astorkiza 2014], Mexico City Spanish [Schmidt & Willis 2011], Highland Colombian Spanish [García 2013], and Quito Spanish [Strycharczuk et al. 2014]) has revealed that this categorical presence of [z] before voiced (semi)consonants and [s] everywhere else is merely an idealized characterization of the actual phonetic variability that exists in real speech, which instead boasts both voiceless and voiced productions in all contexts. As Clegg & Strong (1992:32) note, “There is no question as to the existence of the phenomena of sporadic voicing of /s/ in all positions and extensive voicing in some speech communities.”

This more sporadic characterization of /s/ voicing, outside the context of a following voiced (semi)consonant (e.g., intervocalic position), is traditionally characterized as a result of endogenous or language-internal tendencies (Obaid 1973; Torreblanca 1978). Indeed, the variable voicing and devoicing of alveolar fricatives has been touted as a diachronically natural fluctuation in Romance, evidenced for example in the evolution of ‘house’ from Latin (/kasa/) to Old Spanish (/kaza/) to Modern Spanish (/kasa/) (Penny 2002:98–103; Hualde & Prieto 2014:111). In intervocalic contexts, the voicing of /s/ to [z] can be characterized as a product of lenition, modeled within a framework of gestural phonology (Browman & Goldstein 1989) as a consequence of conflicting laryngeal gestures for [s] (vocal fold abduction) and a following voiced vowel (vocal fold adduction), which can give rise to gestural blending that results in a single vocal fold adduction gesture that gradiently extends into the /s/ segment, yielding voiced [z] (Romero 1999; Campos-Astorkiza 2014:19; Hualde 2014:107). Faster speech rates and more casual speech styles have often been linked to greater voicing rates (Torreira & Ernestus 2012; García 2013; Strycharczuk et al. 2014; Chappell & García 2017; García 2020), corroborating the characterization of sporadic voicing in monolingual varieties of Spanish (e.g., Mexico, Spain, El Salvador, Panama [Obaid 1973; Torreblanca 1978]) as a product of language-internal articulatory lenition. Alternatively, contact-induced motivations for intervocalic Spanish [z] have been posited for Spanish in contact with Catalan (Wesch 1997; Vann 2001; Davidson 2020, 2021), English (Teschner 1996; Schmidt 2008; Menke & Face 2012; Boomershine & Stevens 2021), and varieties of Quechua (Toscano Mateus 1953; Córdova 1996; Davidson 2019a), all of which posit phonemic /z/ in the contact language as a source for transfer into Spanish on the part of Spanish bilinguals.

A series of linguistic variables has been found to consistently mediate variation in Spanish intervocalic voicing, including word position (favoring greater voicing word-finally over word-initially and/or word-medially [Chappell 2011; Davidson 2014, 2019a, 2020, 2021; Hualde & Prieto 2014; Strycharczuk et al. 2014; Chappell & García 2017]), speech rate and style (favoring greater voicing in faster, more casual speech [Torreira & Ernestus 2012; García 2013; Strycharczuk et al. 2014; Chappell & García 2017; García 2020; Davidson 2020, 2021]), and stress (favoring greater voicing across unstressed syllables [Torreira & Ernestus 2012; Davidson 2014, 2019a, 2020, 2021; Chappell & García 2017; García 2020]), whereas the effects of other linguistic variables, such as word frequency and morphological status of /s/, have been less consistent (Chappell 2011; Torreira & Ernestus 2012; Davidson 2014).

On the other hand, social variables found to condition Spanish intervocalic [z] production vary widely by variety. For some variables, such as age, the direction of effect has been consistent across the varieties that exhibit sensitivity, such as greater voicing being uniformly favored among younger speakers in the Spanish of Loja, Ecuador (García 2020) and Barcelona, Spain (Davidson 2020, 2021). For other variables, such as gender, the direction of effect varies across varieties that

show sensitivity, such as greater voicing by male speakers in San José Spanish, Madrid Spanish, and Loja Spanish (Torreira & Ernestus 2012; Chappell & García 2017; García 2020), in contrast with greater voicing by female speakers in Barcelona Spanish (Davidson 2020, 2021).

As regards the social meaning and perception of Spanish intervocalic [z], matched-guise research has recently been carried out for San José Spanish (Chappell 2016), Loja Spanish (García 2019), and Barcelona Spanish (Davidson 2019b). For listeners from San José, Costa Rica, the covert attitudes associated with intervocalic [z] varied significantly by speaker gender, such that an asymmetry in its indexical field was posited whereby male speakers who use [z] are afforded positive evaluations of niceness, localness, confidence, and masculinity, whereas female speakers using [z] are only afforded negative associations of lower education and lower social class. Given the different social meanings accessible to men and women in the indexical field of [z], men are argued to employ [z] more frequently for social gain, while women avoid it to eschew the more negative qualities [z] indexes for women (Chappell 2016:371). This asymmetrical gender-based indexicality was also found for listeners in Loja, Ecuador. Negative covert associations of lower social class and unpleasantness were afforded exclusively to female speakers using intervocalic [z], while affiliations of a more highland (i.e., from Cuenca or Quito) regional origin were afforded to both male and female speakers who use intervocalic [z], where systematic /s/ voicing takes place word-finally (García 2019:146). As such, intervocalic [z] may be an incoming change in progress led by younger Loja men in greater contact with speakers from Quito and Cuenca. Finally, in Barcelona, intervocalic [z] was found to be covertly associated with positive affiliations of Catalan bilingualism and local solidarity, consistent with a change in progress from below led by Catalan-dominant young female speakers (Davidson 2019b:59, 67).

As can be readily observed from the data presented to this point, a plethora of fricative phenomena have been explored across the world's languages, and scholars have applied a range of methods and theoretical approaches to their study. Crucial to the present chapter is the fact that fricative variants often become associated with social meaning. In the specific case of intervocalic /s/ voicing in Spanish that we have highlighted, the social meaning linked with a single variant differs across varieties of the same language. This complex background sets the stage for our case study on sociophonetic variation.

### CASE STUDY Cross-dialectal comparison of intervocalic /s/ voicing in Spanish

Given the geographic extension and social variability of intervocalic /s/ voicing, the variable offers a rich landscape for possible sociolinguistic inquiry, including the interplay between language-internal and language-external factors, language variation and change, and the connection between the social perception of [z] and its usage patterns in the speech community. As a case study in the nature of sociophonetic variation in fricatives, we provide a novel comparative analysis of intervocalic /s/ voicing across datasets exploring three varieties of Spanish: Barcelona Spanish, San José Spanish, and Loja Spanish. A dialectal comparison of this nature provides fruitful insights into the nature of this fricative process and, more specifically, the ways in which the fricative process intersects with social factors. Of particular relevance for the present paper will be gender-mediated variation, which uniquely links intervocalic /s/ production across distinct Spanish-speaking communities. We seek to answer the following question: How do sociolinguistic factors such as gender ultimately account for the divergent linguistic outcomes of a single linguistic variable across three related language varieties?

## Methods

The data for this case study come from semi-spontaneous interview speech from each of the three varieties. The Barcelona Spanish dataset (Davidson 2021) consists of interviews with 48 speakers of Barcelona Spanish from two age groups: 18–30 and 48–60 year olds. The participants in this dataset fall along a continuum of bilingualism ranging from those who are Catalan-dominant to those who are Spanish-dominant, and the sample is balanced in terms of how many participants come from each language dominance group. The San José Spanish dataset (Chappell & García 2017) is composed of interviews with 18 natives of the province of San José, Costa Rica, who are evenly distributed (six speakers per group) among three age groups: under 30, 30–50, and over 54 years old. Finally, the Loja Spanish dataset (García 2020 forthcoming) includes interviews with 31 natives of Loja, Ecuador, relatively balanced between three age groups: under 30, 31–45, and 45–68 years old. All of the San José and Loja participants have Spanish as their first language and, while some have studied English or another language, none consider themselves fluent in English or any other language. All three datasets are balanced for gender, with equal numbers of male and female speakers.

For the San José and Loja datasets, 60 tokens containing intervocalic /s/ were extracted from each interview after the 10-minute mark of the sociolinguistic interview portion, where possible. Token extraction began after the 10-minute mark in hopes that the interviewees would feel more comfortable with the researcher at that point. Of the 60 tokens, 20 came from each of the three word positions: word-medial (e.g., *casa* ‘house’), word-final (e.g., *cas agrio* ‘bitter Costa Rican guava’), and word-initial (e.g., *la sopa* ‘the soup’). In the case of the Barcelona dataset, 20 tokens of intervocalic /s/ balanced for word position (word-initial vs. word-final) and stress were extracted from each interview. The token extraction in the Barcelona dataset was limited to 20 tokens per speaker, as this was the highest number of tokens offered by all speakers that provided a perfectly balanced distribution of tokens per linguistic factor cell. In total, the analysis presented here includes 915 tokens from the San José dataset, 1387 tokens from the Loja dataset, and 960 tokens from the Barcelona dataset.

Following Gradoville (2011), we measure voicing in terms of the percentage of each token’s voiced duration. First, we manually delimited the boundaries of each token of /s/ by examining the waveform and spectrogram to find the points where the aperiodic noise of the fricative begins and ends and the formants of the surrounding vowels disappear and appear. With the boundaries set, the total duration of the fricative was noted. The duration of voicing was then calculated by measuring the portions of the fricative that exhibited periodicity in the waveform and a voicing bar in the spectrogram. Finally, the total voicing duration was divided by the total fricative duration, resulting in percent voicing for each token.

The social factors modeled for all three varieties are gender and age, and language dominance is also incorporated for the Barcelona dataset. The linguistic factors examined consist of word position and stress only for the Barcelona data, and also preceding/following vowel and local speech rate for the San José and Loja data. Additionally, F2 and f0 were examined in the San José analysis. In all models, percent voicing served as the dependent variable and speaker was included as a random effect. The San José and Loja analyses employ inflated beta regression with mixed effects using the package *gamlss* (Rigby & Stasinopoulos 2005) in R (R Core Team 2022), while the Barcelona Spanish analysis employs mixed-effects linear regression using the *lmer* function in the *lme4* package (Bates et al. 2015). The overall results and specific results for each dataset are briefly summarized in the following



section. For complete model outputs for the Barcelona, San José, and Loja data, respectively, the reader should refer to Davidson (2021:109), Chappell & García (2017:23–24), and García (2020:449).

## Results

### *Voicing across varieties*

Figure 8.1 shows histograms of percent voicing for the Barcelona, San José, and Loja datasets. What is immediately obvious in all three histograms is that percent voicing does not constitute a normal distribution. Instead, we observe roughly a bimodal distribution in which there is a peak at 100 percent voicing and another peak around 0–30 percent voicing. Another notable aspect of the histograms is that in all three datasets there are no tokens that fall in the 90–99 percent voicing range. Interestingly, this gap between 90–99 percent voicing has also been found by other scholars who examine percent voicing in Spanish /s/ (e.g., Campos-Astorkiza 2014). This may be attributable to anatomical restrictions in that there is a threshold in which the vocal folds cannot cease vibration for such a short period of time, and thus an intervocalic /s/ that is near-fully voiced becomes fully voiced by default.

Crucial to note, as well, is the fact that the distribution of percent voicing in the three varieties is quite similar in terms of its bimodality. Given that Barcelona Spanish is a contact variety and San José and Loja Spanish are not, we might have expected the distributions to differ. Instead, we see that regardless of contact status, all varieties exhibit a bimodal distribution.

In the case of the Barcelona dataset, the significant social factors conditioning voicing are language dominance, age, and gender (see Davidson 2021). Higher rates of voicing are found in progressively more Catalan-dominant speakers, younger speakers, and among female speakers. More voicing is also found in /s/ between unstressed vowels, characteristic of a lenition or reduction process. Finally, there is significantly more voicing in word-final than word-initial contexts, indeed approaching a categorical absence of fully voiced [z] tokens in word-initial contexts for the majority of speakers, which notably coincides with the site of a phonemic /s/-/z/ voicing distinction in Catalan. This effect of word position interacts with participant language dominance and age, with the strongest effect of word position being found in younger speakers and those with the most exposure to and use of Catalan.

Given the extensive and systematic use of intervocalic /s/ voicing by all Barcelona bilinguals, even those that are Spanish-dominant, this feature appears to be an important regional marker of Catalanian

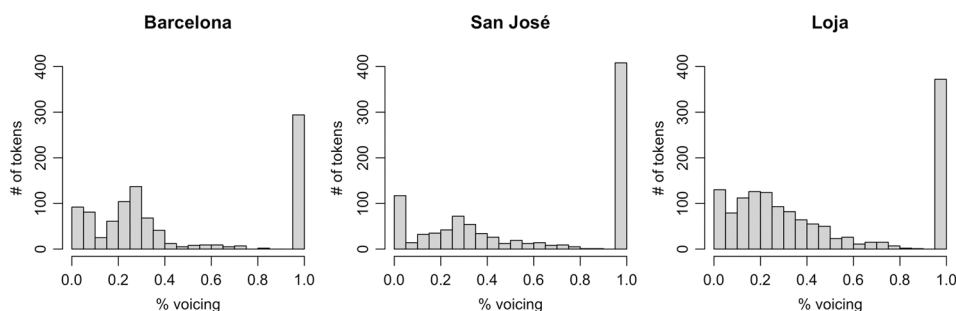


Figure 8.1 Histograms of percent voicing for Barcelona, San José, and Loja

Spanish. Furthermore, because higher rates are found in female speakers and younger speakers, this may represent a change in progress from below. Voicing in this variety lacks overt awareness and negative social stigma, which allows it to take on exclusively positive associations of a bilingual identity and solidarity, in contrast with other phonetic features, like lateral velarization, which align more closely with an overtly negative sociolinguistic stereotype (Davidson 2019b, 2022).

In San José Spanish, as in Barcelona Spanish, intervocalic [z] resembles a reduction process, as higher rates of voicing are found at higher speech rates and between unstressed vowels (see Chappell & García 2017). Additionally, there is more voicing in word-final contexts and there is no effect of preceding/following vowel in the San José data. Finally, because there is no observable effect of participant age, voicing seems to be a case of stable variation in San José Spanish as opposed to a sound change in progress, although this should be confirmed with data from more participants. Finally, both gender and physiology were found to condition intervocalic /s/ voicing in San José Spanish. Greater voicing was observed among men and speakers with larger vocal tracts, which was indirectly established through F2.

As in Barcelona and San José Spanish, voicing can be considered a reduction process in Loja, as it is favored in faster speech rates, between unstressed vowels, and when followed by a non-high vowel (see García 2020). Voicing is also favored in word-initial and final contexts, which is not immediately suggestive of reduction, but the resyllabification of word-final intervocalic /s/ to the onset of a following syllable may encourage some degree of analogical blurring at the word boundary. Social factors also serve to condition intervocalic /s/ voicing in Loja; higher voicing rates were observed among men and younger speakers, which may be indicative of a change in progress led by young men.

To summarize the findings presented thus far, the distribution of percent voicing in the three varieties is quite similar, and we see that they also share some of the same conditioning factors. Voicing in all varieties is favored between unstressed vowels, indicative of a lenition process as a result of gestural blending. On the other hand, the results for word position do differ somewhat, with voicing favored in only word-final contexts in Barcelona and San José Spanish, while it is favored in both word-final and initial contexts in Loja Spanish.

The results for age in Barcelona and Loja coincide, with more voicing among younger speakers, but the effect of age is not significant in the San José data. This suggests, based on the apparent-time construct (e.g., Bailey 2004), that intervocalic /s/ voicing may be a change in progress in Barcelona and Loja, and may represent more stable variation in San José. In all instances, social and linguistic factors work together to condition voicing, but the specific factors at play depend on the dialect. For example, language contact with Catalan has facilitated intervocalic /s/ voicing's ongoing adoption in Barcelona Spanish and heavily restricted it from word-initial contexts that in Catalan preserve a phonemic voicing distinction, while in Loja Spanish, increased contact with neighboring Highland Ecuadorian dialects that have systematic voicing has promoted the propagation of systematic voicing into the Loja community.

### *Effects of gender in the three varieties*

Given its crossdialectal importance with regard to intervocalic /s/ voicing and to fricative processes cross-linguistically, gender merits a more thorough exploration. The particular effect of gender on intervocalic /s/ voicing differs according to the variety, with voicing favored by female speakers

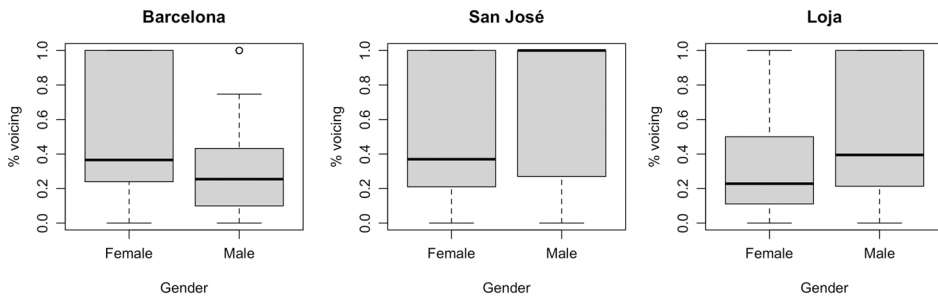


Figure 8.2 Boxplot of percent voicing by gender for Barcelona, San José, and Loja

in Barcelona and, conversely, favored by male speakers in San José and Loja. To examine this difference further, Figure 8.2 displays boxplots of percent voicing by gender for each of the three varieties.

These boxplots show us that gender patterns in Barcelona and Loja are essentially mirror images of each other. In Barcelona, female speakers have a wider range of voicing with a significantly higher median voicing than male speakers, while male speakers in Loja have a wider range of voicing with a significantly higher median voicing than female speakers. On the other hand, female and male speakers in San José have similar ranges of percent voicing, but the median voicing of males is significantly higher than that of females. The different gendered patterns observed in these datasets, even for dialects where voicing appears to be led by men, suggest that the “gender effect” warrants deeper scrutiny in order to fully understand both the range of voicing and median voicing.

## Discussion

Certain linguistic factors related to articulatory phenomena condition intervocalic /s/ voicing similarly across Barcelona, San José, and Loja Spanish—for example, gestural blending results in greater voicing between unstressed vowels in each variety. However, the effect of gender is markedly distinct across these dialects, with women as the predominant voicers in Barcelona and men leading voicing in Loja and San José. Furthermore, even in Loja and San José, the particular gender patterns are not identical, as both women and men in San José exhibit the full range of voicing (0–100 percent), albeit with different median percent voicing, whereas only men in Loja demonstrate this same full range of voicing.

How, then, can we account for the emergence and spread of the same phonetic innovation, which exhibits such divergent behavior, across three varieties of the same language? In addition to the phonetically motivated /s/ to [z] reduction between vowels, particularly between unstressed vowels and word-finally, several scholars have proposed that the origin of some linguistic features may be the result of physiology. For example, palatal morphology can affect individuals’ realizations of the /s/-[ʃ] contrast in German (Weirich & Fuchs 2013) and, in the case of intervocalic consonant voicing, larger vocal tracts hinder the rapid cessation of vocal fold vibration between vowels (Nadeu & Hualde 2014), resulting in greater gestural overlap in men’s speech, who tend to have larger vocal tracts. In San José Spanish, vocal tract size and gender (male or female) were both found to condition intervocalic

/s/ voicing similarly, with vocal tract size offering a slightly better fit for the data in model construction (Chappell & García 2017). However, distinguishing between gender-based social motivations and physiological motivations is a tall order, as these categories tend to overlap and intersect, and other conditioning factors beyond physiology likely play a role as well. This disjuncture between physiology and productions has been identified in other aspects of articulation; for example, Fuchs et al. (2015) contend that f0 declination in German (and likely in other languages) is not purely rooted in breathing; this physiological factor appears to interact with speech style and pragmatic communicative constraints.

Although physiological explanations (men with larger vocal tracts exhibit greater voicing) and general lenition tendencies (greater reduction takes place between unstressed vowels) may account, to some extent, for the behavior of intervocalic /s/ voicing in San José and Loja Spanish, this argument is especially complicated by the Barcelona data. In Barcelona, women produce greater rates of [z], belying the notion that intervocalic /s/ voicing pervades men's speech more than women's as a consequence of having originated physiologically in male vocal tracts. Additionally, a comparison of voicing patterns in San José and Loja demonstrates differences as well, with more gradient voicing in Loja and more categorical voicing in San José.

Sociophonetic perception studies can shed light on the social meaning (or lack thereof) motivating the behavior of the same phonetic variants in different environments. Based on perception studies of intervocalic /s/, we argue that differing local societal conditions and norms give rise to the distinct gender patterns observed in our datasets. What appears to originate as a result of phonetic, physiological, or phonological factors (that is, the result of articulatory forces, the body, or bilingualism) becomes imbued with social meaning specific to the local context, instantiating three unique trajectories. In San José Spanish, /s/ voicing represents stable variation that has become associated with male speakers, whereby male speakers that use [z] are perceived as nicer, local, confident, and masculine, and female speakers using [z] are heard as less educated and from a lower social class (Chappell 2016). Accordingly, female speakers tend to avoid this variant, as its use triggers negative associations among local listeners.

By contrast, apparent-time analyses in Barcelona and Loja Spanish suggest a change in progress may be taking place. As such, the different indexical fields that are emerging for the variable in each locality influence how the change progresses and patterns in the broader social fabric. For Barcelona, the indexical field of intervocalic [z] features exclusively positive associations with bilingualism and local solidarity, which sanction its gradual adoption in the speech community, unlike other phonetic markers of Catalanian Spanish that are the topic of overt social ridicule (Davidson 2019b, 2021). In Loja, men's use of intervocalic [z] is seen as unnoteworthy and is not strongly associated with most of the social characteristics examined, while intervocalic [z] makes female speakers sound less pleasant, lower status, and younger (García 2019). Additionally, this variable serves as a marker of regional identity, with voicing being associated with neighboring Highland Ecuadorian dialects (Cuenca and Quito) that exhibit systematic voicing. García (2020) hypothesizes that young men are the leaders of this change, largely due to the fact that they are in greater contact with these highland varieties. Looking at the intersection of age and gender, she shows that the mean voicing rates of females are roughly two age groups behind those of males; in other words, it is not necessarily the case that Loja women are avoiding voicing like the San José women, but rather that they are further behind in the adoption of the incoming variant. In both communities, Barcelona and Loja, this variable is not particularly salient for

naive native speakers. Regardless of its salience, the hyper-local interaction with gender still dictates unique production patterns and social meanings.

Silverstein's (2003) orders of indexicality may further clarify the directionality of the development of intervocalic [z] across these varieties: in San José, intervocalic [z] came to be associated with men and later adopted social meanings frequently associated with men in the region, including localness, confidence, and masculinity. In Barcelona, intervocalic [z] indexes a local Barcelona identity, and the variant then acquires positive associations with bilingualism and cultural pride. Unlike San José Spanish, where [z] became intertwined with masculinity and ideologically connected characteristics, essentially precluding the variant's use among women, women in Barcelona were able to harness the cultural capital of intervocalic [z], which could be used to signal their local pride and fluency in Catalan. Finally, intervocalic [z] in Loja appears to be less advanced along the linear order of indexicalities, mainly evoking evaluations of regional highland identity, and young men appear to be producing greater rates of voicing as a result of greater contact with Highland Ecuadorian Spanish speakers from places outside of Loja. In time, intervocalic [z] in Loja may become associated with other social qualities linked with Highland Ecuadorian Spanish speakers or with young men in Loja. This remains to be seen, but what is clear is that the ideologically related meanings associated with intervocalic [z] across these varieties, their indexical fields (Eckert 2008), vary as a result of the social fabric in which each variant resides and stand to be continually reinterpreted through ongoing social interactions.

### The future for fricatives

This concise literature review and case study have served to grapple with the complex push and pull between social and linguistic factors in the study of fricative phenomena and, more specifically, to home in on the local societal conditions that cause a single linguistic variable to evolve distinctly in different Spanish-speaking communities. While the novel case study has offered some insight into why gender patterning is quite different across the three varieties explored, it also suggests the need for more nuance in the way that we conceptualize social factors, such as gender, that have an influence on fricative phenomena.

Based on the types of data presented in the case study, we are limited to canonical conceptualizations and discussions of gender. Undoubtedly, the future of this field and what will advance the sociophonetic study of fricatives are more “third-wave” (Eckert 2012) studies that consider the role of gender and sexuality beyond fixed social categories. Indeed, it is not only the influence of gender that should be considered as a continuum rather than a dichotomy, but other social factors as well, such as age and social class (Eckert & McConnell-Ginet 1992). Approaching gender as a dynamic entity avoids many of the problematic assumptions that go hand in hand with more traditional accounts, for example, the unmotivated combination of vastly different men and vastly different women or the inability to account for individual identities, personae, or stances in the meaning-making endeavor.

More recent work on /s/ fronting has highlighted this point; for example, drag queens in San Francisco have been shown to alter the amplitude of /s/ as they visually transform themselves using makeup, wigs, and clothing into their feminine drag personae, showing the symbiosis of linguistic and visual presentation (Calder 2019). Zimman (2017) similarly demonstrates that transgender men lower f<sub>0</sub> in the production of /s/ as a function of how long they have been undergoing testosterone therapy, ultimately arguing for a re-theoretization of gender as a fluid kind of



sociolinguistic style. The ongoing, more third-wave reconceptualization of social categories as inherently gradient will inevitably need to reconcile, on the one hand, these fluid categories as integral to the highly dynamic process of linguistic variation and identity construction at the individual level with, on the other hand, community level, aggregate patterns of language variation and change that rise above the incredible diversity of social identities and processes of meaning construction of its individual speakers.

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