A subsegmental approach to coda /s/ weakening in Dominican Spanish

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Abstract

Analyses of the variable weakening of coda /s/ in Spanish have largely relied on a categorical conception of variability. While categorical descriptions have proven to be useful heuristics, they have nevertheless tended to obscure important facts about phonological variation and the factors that probabilistically condition it. A growing body of research on sociophonetic variation offers evidence that correlations between linguistic forms and social factors can be manifested in fine-grained subsegmental aspects of speech. The current study conducts a subsegmental analysis of coda /s/ in the speech of five Dominican women. Instrumental analysis of 625 tokens: (1) demonstrates that a strictly segmental description groups together tokens that are significantly different from one another acoustically; (2) offers an instrumentally-based, alternative description of coda /s/ tokens in terms of two continuous, acoustic measures, duration and center of gravity; and (3) argues that a subsegmental approach is better at describing the variation present in speech, and also better exploiting the explanatory power of several linguistic factors known to condition the phenomenon. As a result, the present analysis offers a more accurate picture of the Spanish of Dominicans in New York, and provides a model for greater descriptive and explanatory adequacy in the study of Spanish in general.

Keywords: Spanish; New York; sociophonetics; coda /s/.

1.   Introduction

Few variable speech phenomena have received as much attention as coda /s/ weakening in Spanish. The extensive study of variation in the pronunciation of /s/ in words like *hablas* 'you speak' and *mismo* 'same' has produced an illuminating and rich body of work. Though the picture of coda

/s/ that emerges from this research often differs across groups of speakers and geographic locations, what binds these analyses together is a shared description of the object of study. That is, most previous research on coda /s/, whether conducted under a formal generative model or within a Labovian variationist paradigm, treats the phenomenon in categorical terms. Or, saying it in somewhat more technical terms, it is typically presumed that variation in the phonetic implementation of coda /s/ can be adequately described segmentally. The /s/ of *hablas*, for instance, is described as being either fully articulated as [-s], reduced to aspiration as [-h], or deleted completely (Cedergren 1973; Guitart 1976; Lipski 1985). The purpose of this paper is to challenge and offer an alternative to this way of studying /s/ weakening.

Foremost among reasons for doing so is the fact that in recent years the analysis of variability in phonetics and phonology has considerably expanded its scope. Much of this expansion has been made possible by the development of computer-based techniques for instrumentally measuring the acoustic-phonetic properties of speech. Such techniques have been particularly exploited by researchers interested in examining socially-conditioned variation in speech sounds, or ''socio-phonetic variation'', from a perspective that looks beyond the boundaries imposed by segmental descriptions. Among the most compelling and often replicated findings to emerge from socio-phonetic research is that correlations between linguistic form and social factors can be manifested not only at the level of the segment but also in fine-grained, subsegmental aspects of speech (Di Paolo and Faber 1990; Foulkes and Docherty 2006; Fourakis and Port 1986; Kerswill and Wright 1990; Thomas 2000). That is, instrumental analysis has proven capable of uncovering systematic socio-phonetic variation within a single segmental category and also across more than one segmental category (for a review of supra-segmental variation see Foulkes and Docherty [2006]).

Given these findings and the abundant evidence that, whether described segmentally or subsegmentally, coda /s/ weakening is at least to some extent conditioned by social factors (see below), it is essential to determine whether instrumental analysis of this phenomenon reveals systematic patterns otherwise obscured by segmental description. The discovery of systematic acoustic variation within identically categorized segmental variants of coda /s/ expression would be of significance not only to the study of variation in Spanish but also to socio-phonetic research in general. With regard to Spanish, coda /s/ weakening has been central in the study of dialectology and sociolinguistics in both Latin America and Spain: the different probabilities of appearance of /s/ variants constitute one of the most important ways of distinguishing between dialectal

varieties (Alba 1990; Cedergren 1973; Hammond 1980; Lipski 1994; Terrell 1978, 1994; Wigdorsky 1983; Zamora and Guitart 1988) and of understanding how Spanish speakers of differing region, gender, age, and socio-economic background establish and maintain membership in the speech communities to which they belong (Alba 1982, 1990; Cameron 1996; Cedergren 1978; Cepeda 1995; Fontanella de Weinberg 1974; Terrell 1977; López-Morales 1983). This fact is of particular importance for the study of Spanish in situations of language and dialect contact. In such cases, tracking shifts or maintenance of patterns in /s/ production is crucial to identifying the formation of new speech communities and for characterizing contact varieties of Spanish. For this reason, the current study draws its data from Spanish speakers living in New York City (NYC), a highly multilingual environment in which speakers are exposed not only to numerous varieties of Spanish but also to the influence and pressure of English.

That being said, it is not yet the goal of this paper to present a picture of /s/ as it is expressed across a range of social categories or through degrees of language and dialect contact. Rather, it is to take the first step toward that goal by re-assessing the way in which this important variable phenomenon has been examined by researchers. To the extent that a segmental description of /s/ weakening conceals important patterns present in speech, explanations of variable linguistic behavior based on such descriptions are incomplete. As such they provide less than ideal means for understanding a key aspect of not only Spanish in NYC, but in non-contact varieties of Spanish as well. Beyond the current study and with respect to socio-phonetics at large, instrumental analysis of variable /s/ weakening begins to address the fact that most research of this kind has "been skewed, with a focus on English and relatively little instrumental analysis beyond vowels" (Foulkes and Docherty 2006: 432).

2.   Motivating the current study

Any researcher who has attempted to assign /s/ tokens to one of three segmental phonetic categories knows firsthand that the distinction between [-s] and [-h] is often difficult to ascertain, and that differentiating between aspiration and deletion can sometimes be an impossible task. Advances in socio-phonetic methodology make it easy to see why. Consider the image in Figure 1.

This image was created by *Praat*, a widely used, free scientific computer software program for the phonetic analysis of speech that was designed and is continuously updated by Paul Boersma and David Weenink
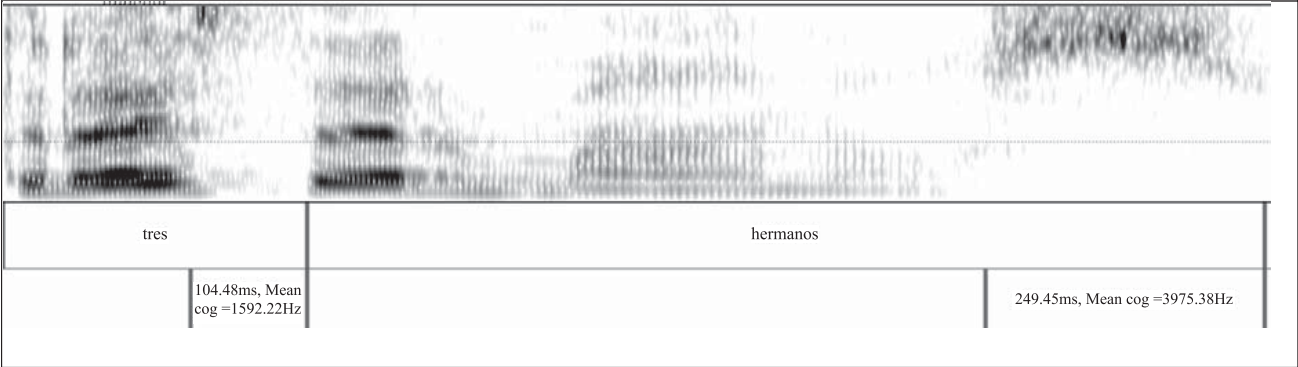
Figure 1.   Praat *image of* tres hermanos *'three siblings'*

of the University of Amsterdam. Here, *Praat* provides a visual representation of the acoustic-phonetic properties of the phrase *tres hermanos* 'three siblings' which was extracted from an interview with a female Dominican subject (one of five from whom coda /s/ data was drawn for the purpose of this study). At the segmental level, the description of the /s/ of *tres* and the /s/ of *hermanos* is identical. Both are examples of the [-s] variant. However, these two tokens are clearly different at the subsegmental level. This is apparent in that the band of fricative energy which represents the phonetic implementation of /s/ is darker, longer and less diffuse in *hermanos* than it is in *tres*. This reflects differences in two acoustic dimensions; namely, the temporal and the spectral. Two measures for quantifying temporal and spectral properties are *frication duration* and *center of gravity* (COG). The first measure, duration, is self-explanatory. The second, center of gravity, is a way of identifying the frequency at which sonic energy is maximally concentrated. It is a weighted average calculated with the equation $COG = \sum fI / \sum I$ where *I* is the amplitude in decibels and *f* the frequency in Hertz of the spectral components.

These two measures are regularly used in socio-phonetic research and have already been exploited in laboratory studies of /s/ in Spanish.[1] Both duration and COG can be precisely calculated in *Praat*. Regarding the tokens above, the /s/ of *tres* is 104.48 milliseconds long and has a COG of 1592.22 Hz. By comparison, the /s/ of *hermanos* lasts for 249.45 ms and has a COG of 3975.38 Hz. As these tokens illustrate, instrumental analysis provides an objective and reliable way of uncovering, capturing, and quantitatively expressing differences in acoustic properties that are otherwise obscured at the outset of segmental analysis.

The next step is to determine whether this approach is in any important way better for studying variation in /s/ production. That this is the case is not true necessarily or by definition. In and of itself, the presence of category-internal acoustic variation is unsurprising. No two utterances are ever acoustically identical, and instrumental analysis may simply be a good tool for capturing random acoustic variation that results when phonological knowledge is phonetically implemented. However, if differences such as those observed above are not random, but instead are systematic and reliably predictable in statistically significant ways on the basis of other information, then it may be argued that purely segmental analyses of /s/ weakening artificially diminish the amount of patterned variation actually present in speech. To the extent that it does so, segmental description may also reduce the predictive power of factors known to condition the phenomenon.

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3.   Design and methodology

Recall that it is not the goal of this study to characterize the way in which /s/ weakening indexes regional and social categories across or within a given population of Spanish speakers. Rather more modestly, the goal is to determine whether segmental description of /s/ weakening obscures systematic acoustic variation present in Spanish speech and also whether it hinders our ability as researchers to predict and explain such variation. This can be investigated most efficiently by: (a) describing a set of coda /s/ tokens in the two ways discussed above — segmentally and also sub-segmentally; (b) coding those tokens for several language-internal factors known to constrain /s/ weakening; and (c) comparing the descriptive and explanatory efficacy of the two methodological approaches. The next section addresses (b) by briefly reviewing the literature on language-internal factors that have been shown to condition /s/-weakening.

3.1.   *Language internal constraints on /s/ weakening*

Studies of language-internal constraints have explored a broad range of phonological and morpho-syntactic factors. Given the wide variety in the location, size and homogeneity of the speech communities studied, it is not surprising that research results regarding the factors that constrain /s/ expression are sometimes different and even contradictory. With regard to phonological predictors, many studies have replicated the findings of Ma and Herasimchuk (1975) and Poplack (1979, 1980), showing that /s/ is more likely to be weakened, i.e. aspirated or deleted, when preceding a consonant than when preceding a vowel (Alba 2000; Terrell 1978) and similarly more likely to be weakened when preceding a consonant than when preceding a pause (Alba 2000; Lipski 1985, 1987; but see slightly different results in Brown and Cacoullos [2003]). For example, in the noun phrase *las buenas escuelas* 'the good schools', the /s/ in *las* and the first /s/ in *escuelas*, which both precede consonants, are more likely to be weakened than the /s/ in *buenas*, which precedes a vowel. Even more specifically, File-Muriel (2007) reports that the manner of articulation of following consonants conditions weakening; while following fricatives favor weakening, following stops disfavor weakening.

It has also been widely observed that the word-position of /s/ affects the probability that it will be weakened. Most studies are consistent with the findings of Hammond (1980) that /s/ is more likely to be aspirated or deleted word-finally, as in *las*, than word-medially, as in the first /s/ of *escuelas* (but see Alba's [2000] study of Dominican newscaster speech

for opposite results). With respect to prosodic conditioning factors, several studies, including Brown's (2005) study of syllable-*initial* /s/ weakening, have found higher rates of weakening in unstressed environments (Brown and Cacoullos 2003; Poplack 1981; Terrell 1978).

With regard to the morphological predictors, most hypotheses in this domain, in Spanish and other languages, can be described as broadly functional. Within morpho-phonology, functional thinking has its most well known formulation in the *Distinctiveness Constraint* (Kiparsky 1982), which states that semantically relevant information tends to be retained at the surface level. It has been claimed that in languages characterized by variable weakening of coda segments, morphemic segments are more likely to be retained than those that are non-morphemic. A classic example of evidence for this claim comes from Labov et al.'s (1968) study of coda cluster simplification in teenage African American English Vernacular, which shows that speakers are less likely to delete final consonants when they bear the role of past tense markers, and particularly when they are the only formal indication of past tense (e.g., non-morphemic /t/ in *list* is more likely to be deleted than morphemic /t/ in *missed*).

Functional explanation in the study of the morphological predictors of /s/ weakening has yielded inconclusive results. Hundley (1987) found, counter-functionally, that for Spanish in Peru morphemic status did not inhibit deletion of coda /s/, that is, that the plural /s/ of *casas* 'houses' is not deleted any less than that of *viernes* 'Friday'. Uber (1981) showed in her study of Puerto Rican Spanish that weakened tokens do not elicit some other phonetic modification to maintain grammatical or semantic distinctions. Earlier, Poplack (1980) had also found, counter-functionally, that /s/ is less likely to be aspirated or deleted in non-morphemic environments like *viernes* than in morphemic environments, including both nominal inflections such as *casas* 'houses' and verbal inflections such as *cantas* 'sing (second person singular)'. Furthermore, Poplack reports that within plural NPs, when preceding words show deletion — i.e. when the /s/ in *las* of *las casas* is deleted — the following words do not show a tendency to repair the ambiguity between plurality and singularity by showing up with an [s]. However, in the same study Poplack did find that the presence of additional plural information, whether morphological or non-morphological, favors deletion somewhat, whereas absence of additional plural information disfavors deletion. This too was successfully replicated by Hundley (1987). Counter-functional findings similar to those of Hundley and of Poplack are reported in Ranson (1992), who found that the greater distinctiveness of masculine plural articles with regard to their singular counterparts (*el* masculine singular vs. *los* masculine plural) when compared to feminine articles (*la* feminine singular vs. *las* feminine

plural) did not have the expected effect on /s/ weakening in articles or their accompanying nouns. With specific respect to coda /s/ in verbal inflections, Hochberg (1986) found evidence for "functional compensation" in Puerto Rican Spanish. Specifically, she found that second person singular verbs ending in aspirated and deleted /s/ tokens are more likely to occur with overt subject personal pronouns than verbs ending in [s].

That Cameron's (1996) study was unable to replicate Hochberg's findings is testament to the fact that consensus on this issue remains elusive. A likely contributor to these contradictory findings is that they are, to some extent, the result of bivariate analytical approaches. Poplack does not explain whether the higher rates of [s] in non-morphemic cases might be due, for example, to the fact that perhaps morphemic /s/ tokens are more frequently followed by consonants, which favors weakening, than are non-morphemic tokens. Secondly, and more crucially, there is disagreement regarding the communicative status of [h]. For example, Poplack and Hochberg disagree on whether aspiration can be viewed as maintaining semantic contrasts. Poplack groups [h] with [s] in this regard while Hochberg groups [h] with [-∅].

3.2.   *Participants and speech materials*

The five speakers whose speech is analyzed for this study are women born in the Dominican Republic who currently reside in NYC. All have lived in New York City for less than four years. Their interviews are taken from the Otheguy-Zentella corpus of Spanish in New York.[2] Subjects were interviewed in a comfortable setting using a conversation-like style. Interviews were recorded on analog cassettes and subsequently digitized using Sony Sound Forge at a sampling rate of 88,200 Hz.

3.3.   *Procedure and analysis*

Each coda /s/ specified in the phonological representation of the words spoken by the subjects was considered. For example, each /s/ in the phrase *las buenas escuelas*, 'the good schools' was included in the study. A total of 125 tokens was collected from each of the five subjects. Each token was then described segmentally on the basis of perceptual coding. That is, tokens were listened to and then assigned to one of three categories: unweakened, aspirated, or deleted. Next, tokens were examined in *Praat*, using a wide band spectrogram. The window length was 0.005 seconds with a dynamic range of 40 dB. The spectrogram method was set for

Fourier Analysis and a Gaussian Window shape. Pre-Emphasis was set at 6 dB/oct.

Determining the boundaries of the fricatives involved consultation of both the spectrogram and the waveform of each token. When the token at hand displayed characteristic fricative energy, its onset was determined by the cessation of the F2 of the preceding vowel and the initiation of the high frequency frication. The offset was determined by the beginning of the F2 if the following segment was a vowel or the cessation of frication if the following segment was a stop or pause. The weakened /s/ tokens were more challenging to pin down and define. Though some frication may be visible in the spectrograph of such tokens, clearer information can be obtained from the waveform. This is because a drastic change in waveform is a reliable indication of the onset of /s/; since all tokens occurred in coda position, they each represented a shift from vowel to consonant. As that transition occurs, the waveform peaks change shape and decrease in height. The point at which that change begins was considered the onset of the token. The offset was identified as the point at which the wave changed shape again, either diminishing before a pause or ending suddenly in the case of a stop or morphing into the next waveform in the case of nasals and vowels.

Tokens were bounded off using interval tiers on a textgrid, as shown in the illustration of *tres hermanos* in Figure 1. Three *Praat* scripts were created to automate measurements. One measured the duration in seconds of each segment marked off in the text grid. Seconds were converted into milliseconds for clearer results. Another pair of scripts was used to measure COG. One identified three points in each token: the midpoint of frication, a point half-way between the midpoint and the onset of frication, and another between the midpoint and the offset of frication. Another script took a spectral slice at each of these points, creating an object in the window for each slice, then calculated the COG for each slice. COG weighting was set to a power of 2.0. Tokens for which there was no evidence of phonation, that is, "deleted" tokens, received a duration measurement of 0 ms but were assigned a value of "undefined" with respect to COG.

Once described both segmentally and instrumentally, tokens were coded for the study's independent variables, each of which belonged to one of two classes: those that describe the phonological context in which an /s/ occurs and those that describe the morpho-syntactic properties of the /s/ token in question.

Regarding the phonological context, each token was coded for the following two variables. (1) *Position of /s/ in the word.* This variable distinguishes whether the /s/ occurs word internally, as in *mismo* 'same',

or word finally, as in *sabes* 'you know', or *las* 'the'. (2) *Phonological identity of surrounding segments*. This variable identifies whether the segments surrounding the /s/ token under study are consonants or vowels; when /s/ occurred phrase finally, the *following segment* was coded as a pause.

With regard to the second class of independent variables, those referring to the morpho-syntactic properties of each /s/, tokens were coded for the following four different properties. (1) *Morphological role*. As discussed above, in word final position /s/ can serve two morphological purposes, that of a plural marker, *casa* 'house' vs. *casas* 'houses', and that of verbal inflection, *canta* 'she sings' vs. *cantas* 'you sing'. However, coda /s/ is not always morphemic. It is never morphemic word-medially, as in *mismo* 'same'. Nor is it morphemic in word final position for a large number of lexical items such as *viernes* 'Friday', *tres* 'three', *luz* 'light', *más* 'more'. (2) *Plural marking*. For words that end in a vowel, such as *casa* above, /s/ serves as the sole formal indicator of plurality, i.e. *casa* vs. *casas*, and *la* 'the' (singular feminine) vs. *las* 'the' (plural feminine). In other cases, /s/ is a formally redundant plural marker; in words that end in consonants, plurality is marked by /s/ and an epenthetic vowel, *red* 'net' vs. *redes* 'nets', or plurality is indicated by a different lexical item entirely, *el* 'the' (sg. masc.) vs. *los* 'the' (pl. masc.). (3) *Verbal inflection and subject pronouns*. Two types of verb forms, second person singular and first person plural, end in /s/. The study recorded whether subject personal pronouns are present or absent with such forms, e.g., (*tú*) *cantas* 'you sing' and (*nosotros*) *cantamos* 'we sing'. (4) *Noun phrase position*. Adjectives, determiners, and possessive pronouns agree in number with the head of a noun phrase. As such, plural marking /s/ is specified by the phonology for each lexical item in an NP with a plural head. The study recorded the linear position of each lexical item in the NP, where *mis* in *mis mejores amigos* 'my best friends' is linearly first, *mejores* second, and *amigos* third.

4.   Results

4.1.   *Comparing the descriptive adequacy of segmental and instrumental approaches*

Regarding the possibility that systematic patterns in /s/ weakening are obscured by segmental description, the study returned two kinds of relevant results. The first is the presence of significant variation internal to segmental categories. The second is the finding that some conditioning

factors only promote weakening in either the spectral or the temporal domain, but not in both. To the first point, since variation internal to the segmental categories is to be expected given the acoustic-phonetic nature of this study's approach, the important question is whether the observed variability constitutes anything other than the sort of acoustic fluctuations that inevitably occur when linguistic knowledge is deployed in space and time. In other words, do two or more tokens that are identical when conceived of as segments differ significantly when described in terms of their acoustic properties? Results indicate that they do indeed. In these data, this finding is clearest for those tokens considered unweakened at the segmental level, that is, those tokens coded as [-s]. Within this class of tokens there are significant differences in frication duration as well as in COG. Furthermore, these differences are clearly correlated with several of the independent variables in the present investigation.

For instance, [-s] tokens occurring word finally, as in *viernes*, were longer in duration ($M = 138.83$ ms $SD = 7.8$) than those occurring word internally, as in *mismo*, ($M = 55.8$ ms $SD = 2.3$), $t(31) = 4.59$ $p < .001$. Also, COG was higher for word final [-s] tokens ($M = 1757$ Hz $SD = 102.5$) than for those occurring word medially ($M = 1051$ Hz $SD = 775$), $t(31) = 2.236$ $p < .033$. Furthermore, [s] tokens preceding pauses were longer in duration ($M = 129.08$ ms $SD = 56.8$) than those occurring before vowels ($M = 81.04$ ms $SD = 36$), which were themselves longer than those preceding consonants ($M = 56.25$ ms $SD = 24.9$), $F(2,166) = 48.12$ $p < .001$. In addition, post-hoc tests show that [-s] tokens are durationally three-ways distinct when compared on the basis of the variable *f following segment*. For these same tokens, COG is lowest before consonants ($M = 990.8$ Hz $SD = 636.96$) and highest before pauses ($M = 1386$ Hz $SD = 722.62$), $F(2,166) = 3.38$ $p < .036$. Moreover, post hoc tests show that with respect to COG, [s] tokens preceding vowels ($M = 1166.1$ Hz $SD = 938.35$) are not different from those preceding consonants.

This finding demonstrates that some conditioning factors only promote weakening in one dimension of the subsegmental description. When a token that is segmentally categorized as [-s] precedes a consonant, it is in fact quite different from (significantly shorter than) the segmentally identical [-s] token when it appears before a vowel. However, these same tokens are indistinguishable with respect to their COG. In other words, the phonological environment affects /s/ temporally but not spectrally. This fact gets to the heart of the matter: it is not just that classifying tokens in terms of segmental alternations makes for internally heterogeneous groups. Analyzing the data segmentally also oversimplifies what it means to be "weakened" in the first place. Put another way, the data

shows that weakening happens to varying degrees in both the temporal and spectral dimensions.

Nor is it the case that conditioning factors have the same effect in each dimension. This finding emerged repeatedly in the results, and it was not restricted to phonological context variables. For instance, regarding NP position, frication duration significantly decreases as linear NP position increases. That is, in a phrase like *las buenas escuelas*, the first /s/, on average, will be longest, the second will be shorter, and the third will be shortest: First Position, (N = 118, M = 50.13 ms SD = 42.47), Second Position, (N = 101, M = 47.73 ms SD = 45.1), Third Position, (N = 33, M = 25.47 ms SD = 35.11) $F(2,239)$ = 3.212, $p < .04$. However, there are no significant spectral differences to speak of with respect to this conditioning factor.

The preceding discussion makes a strong case. Subsegmental analysis of /s/ weakening is more descriptively adequate than segmental analysis. It does not simply capture the phenomenon in greater detail but suggests that /s/ weakening is, in fact, more appropriately viewed as a multi-dimensional acoustic phenomenon which is better expressed along a continuum than in the discrete units of segmental alternation. To illustrate this point more fully, consider Figure 2. The image depicts the three dependent variables of the study simultaneously. COG is represented on the *x*-axis and duration on the *y*-axis. Each object in the field represents a single token that, on the basis of instrumental analysis, exhibited (either in its waveform or spectrograph) energy characteristic of frication. Of these tokens, those that were perceptually coded as [s] are represented by circles. Those coded as [h] are ovals, and tokens perceived as deletions are triangles. (Note: this means that some tokens perceived as deletions, when subjected to instrumental analysis, were determined to exhibit signs of fricative energy.) Excluded from the Figure are 135 cases both perceptually coded and determined by instrumental analysis to be deletions. These cases either have no phonetic realization whatsoever (as in cases where a word like /mismo/ 'same' is clearly articulated as [mimo]) or have acoustic properties indistinguishable from noise in the background of the recordings.

In setting aside tokens that demonstrate no instrumental evidence of fricative energy, Figure 2 is not meant to deny that deletion occurs. Rather, it intends to show that among tokens instrumentally considered to be cases of frication (whether perceptible or not) lenition takes a number of shapes. For instance, weakened tokens can be low in COG, short in duration, or both. And while shorter tokens are often lower in COG, temporal and spectral properties are not perfectly correlated in the data, $r(453) = .65$ $p < .001$. Nor is it necessary for a token to be both tempo-
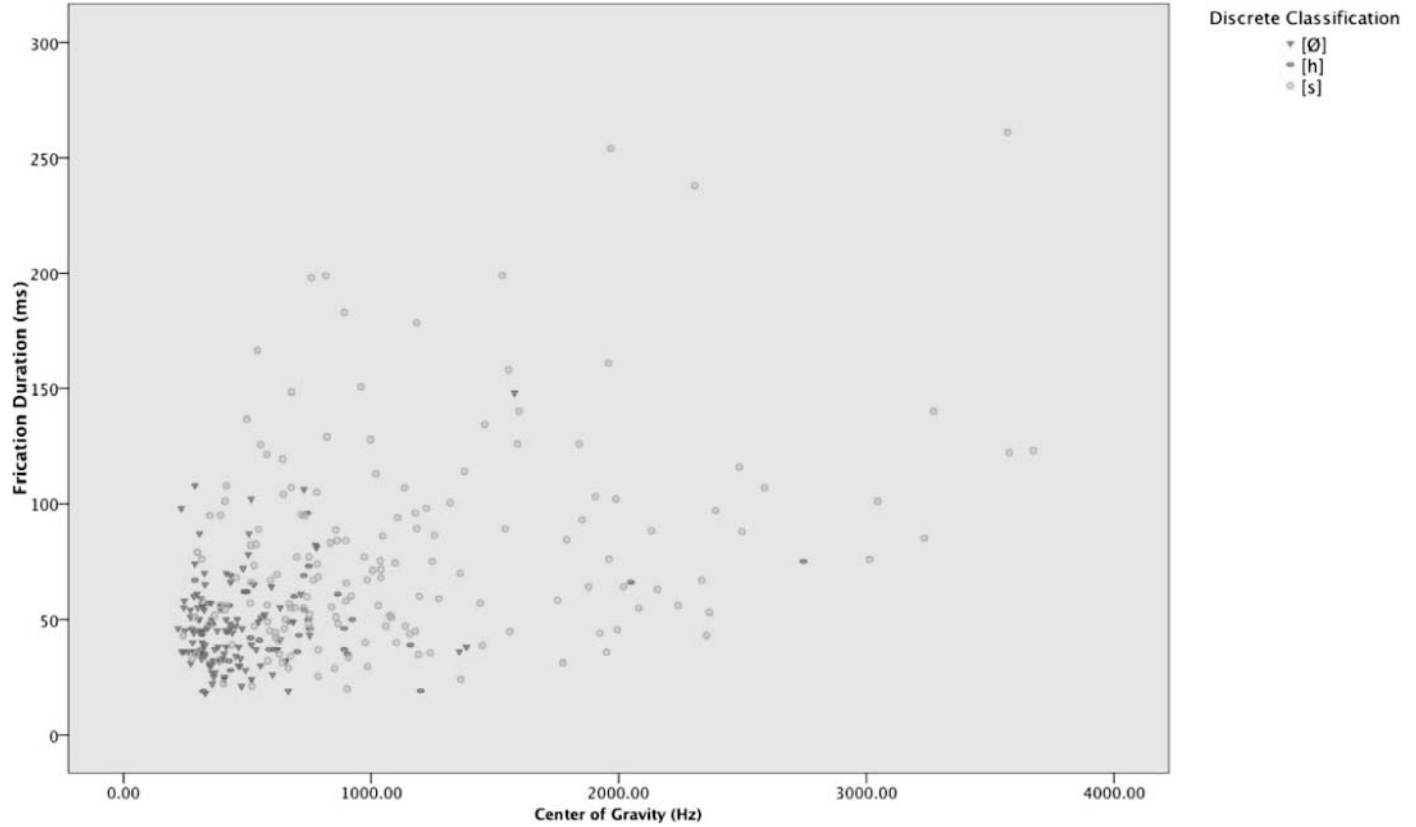
Figure 2.

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rally long and spectrally high for it to be perceived as [s]. Duration of 110 ms or more or a COG of 1800 Hz or higher nearly guarantees that a token will be perceived as "unweakened" according to segmental description. Yet, several of the very long [s] tokens are as low in COG as some of the tokens coded as deletions. Conversely, some cases of [s] are high in COG but just as short in duration as several cases of [∅]. By comparison, perception of deletion and aspiration appear to depend on simultaneous temporal and spectral weakening. With respect to distinguishing aspiration from deletion, the graph suggests that spectral weakening may play a more significant role than temporal reduction. While cases of [h] and [∅] overlap on both axes, the degree of overlap is less intense on the *y*-axis. None of these insights are available on the basis of segmental description.

4.2. *Comparing the explanatory adequacy of segmental and instrumental approaches*

Having shown the clear descriptive advantage of a subsegmental analysis over the segmental one, the next step is to compare the explanatory efficacy of the two approaches. Before presenting the relevant results, the following discussion briefly describes the statistical analyses which make it possible to compare the explanatory power of the two approaches. The best statistical tool for this task is regression analysis. A primary purpose of regression analysis is to create a kind of supervariable from multiple independent variables. That is, if a simple Pearson r coefficient quantifies the linear strength of association between a dependent variable and a single predictor variable, then the purpose of multiple regression analysis is to combine the predictive power of an array of significant predictors (Baayen 2008). Once the relationship between the predictor variables themselves, referred to as their colinearity, has been factored out, what remains is a statistic referred to as "multiple correlation R" or simply R. When R is squared, the value that results is the amount of error, or variance, in the data that is accounted for by the set of predictors. So, a comparison of two different R^2 values is a comparison of how much mystery is left in the dependent variables after each token has been described in terms of the independent variables. The larger the R^2, the more explanatory the analysis.

The method of comparing R^2 values can be straightforwardly applied to the current study. To test the hypothesis that segmental description diminishes the ability of constraining factors to capture systematic patterns in /s/ weakening, one can compare the R^2 results produced by two different regression analyses, one where the dependent variable consists of

segmental description and another one where it is based on the instrumental measures of frication duration and COG.

The two analyses conducted here contained identical independent variables, each known to bear a statistical connection with coda /s/ weakening: *Following segment, Following consonant voicing, Preceding vowel height, Morphemic status*, and *NP-position*. The first analysis, with the traditional, segmental dependent variable, returned a multiple regression equation in which all the independent variables except Morphemic status made a significant contribution to a result of $R = .338$ and $R^2 = .114$. This means that when tokens are described segmentally, knowing about the phonological context of tokens and knowing where a token linearly occurs in an NP accounts for about 11 percent of the variability in the data. The second analysis, relying on subsegmental dependent variables, used Multiple Analysis of Variance (MANOVA) to create a regression equation where the same independent variables contributed to a result of $R = .601$ and $R^2 = .362$, showing that the predictors account for 36 percent of the variability in the data. In other words, the same set of independent variables accounted for three times as much sample variance, 36.2 percent vs. 11.4 percent, when the same data was described using two continuous acoustic measures instead of the single discrete segmental one.

5.   Conclusion

In light of the preceding results, the following conclusions are drawn: (a) the phonetic facts of /s/ weakening are indeed significantly obscured by segmental description; (b) a descriptive metric drawn from widely used methods in socio-phonetic research is substantively different and not simply an alternative notation; (c) instrumental analysis more adequately characterizes the relationship between variation in the acoustic signal and its conditioning factors; and (d) it better positions future research to begin asking how /s/ weakening is perceived, stored, and reproduced by Spanish speakers.

It is important to state firmly and clearly that these conclusions do not in any way invalidate or discredit the large body of work devoted to the study of /s/ weakening at the segmental level. Quite to the contrary, this study would not have been possible without already knowing which language-internal factors were likely to constrain /s/ weakening. That the majority of this study's independent variables emerged as significant predictors of /s/ weakening at the subsegmental level is a testament to the value and credibility of previous research. Furthermore, these conclusions

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suggest that social factors identified by previous work will also prove to be significant in constraining /s/ production at the subsegmental level.

The implications for future study of /s/ weakening are straightforward. Descriptions of dialectal varieties of Spanish, including those in contact settings such as New York City where the present data come from, that make reference /s/ weakening should be reformulated in terms that describe the phenomenon subsegmentally. It is very likely that instrumental descriptions of coda /s/ — whether through re-analysis of existing recordings or through the collection of new data — will more accurately identify patterns of variation and also better exploit the explanatory power of social and language-internal factors that condition /s/ weakening throughout the Spanish-speaking world. With respect to the study of language variation in general and the analysis of variability in phonetics and phonology in particular, this study's findings should be added to the evidence that instrumental techniques are invaluable tools for understanding variable phenomena. Furthermore, they call for continued expansion beyond segmental boundaries and into sub- and supra-segmental levels of analysis.

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Notes

1. In their experimental work, Gerfen (2002), Gerfen and Hall (Forthcoming) use duration and COG to provide instrumentally based accounts of the phonetic implementation of /s/ in Andalusian Spanish.
2. The Otheguy-Zentella corpus contains 141 interviews conducted in New York in Spanish with speakers who trace their origins to six different Latin American countries (Colombia, Cuba, Dominican Republic, Ecuador, Mexico, Puerto Rico). The participants belong to different immigrant generations and, among those of the first generation, have different numbers of years of residence in New York. The interviews were conducted beginning in the year 2000, by Ricardo Otheguy (City University of New York), Ana Celia Zentella (University of California, San Diego), and their graduate assistants, with support from the City University of New York and the National Science Foundation (NSF grant number BCS 0004133). The author is grateful to the principal investigators for the use of the data from the corpus.

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