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Dialectal Differences in Spanish Voiced Obstruent Allophony: Costa Rican versus Iberian Spanish

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Abstract

The Spanish voiced obstruents /b d g/ are traditionally described as having each two allophones: stop and fricative (approximant) in complementary distribution. Several researchers have noted that some Central American and Highland Colombian varieties deviate from the general allophonic distribution in showing a preference for stop realizations in all contexts, except for the intervocalic position. In this paper we report on a large-scale acoustic investigation of /b d g/ in postconsonantal (after a liquid, sibilant or glide) and postvocalic (after /a/) contexts in Costa Rica Spanish, establishing a comparison with the variety of Madrid, Spain, which we take as representative of a variety with the general pattern of allophony. Our study, based on a continuous measurement of intensity, confirms previous descriptions in that Costa Rica Spanish does indeed show a different pattern of allophony from that found in the Madrid variety. The analysis shows that in Costa Rica Spanish postconsonantal realizations of /b/ and /d/ are very different from postvocalic ones, with a clear separation in the degree of constriction between these two contexts. In Madrid, on the other hand, we find a continuum of constriction degrees, depending on the nature of the specific preceding segment, and without a clear separation between postvocalic and postconsonantal realizations. The question that naturally arises is that of the historical connection between these two patterns of allophony, for which we offer some speculation, based in historical parallels and comparison with other varieties.

Introduction

A well-known aspect of Spanish pronunciation is the 'spirantization' of /b d g/, that is, the realization of these phonemes as the continuant consonants [β ð ɣ] in certain contexts. Unlike in languages like French [Duez, 1995] and English [Brown, 1977;

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Browman and Goldstein, 1991; Shockey, 2003], where /b d g/ may be weakened to continuant segments as a sporadic, casual speech phenomenon, in Spanish approximant allophones are found even in careful styles. In, for instance, *sabe* [ˈsaβe] 's/he knows', *lado* [ˈlaðo] 'side', *mago* [ˈmaɣo] 'magician', approximants are the norm also in careful speech. In the intervocalic context, stop realizations would be highly marked or emphatic. Given the general character of the process in Spanish, the distribution of continuant and noncontinuant allophones of the voiced obstruents has been described as a phonological rule [Harris, 1969, 1984; Lozano, 1978; Mascaró, 1984, 1991; Amastae 1986, 1989, 1995; Hualde, 1989; Branstine, 1991; Piñeros, 2002; Barlow, 2003]. The status of the continuant realizations of /b d g/ in Spanish is thus quite different from that of the same segments in French or English.

The traditional description of Spanish spirantization is in terms of two distinct allophones in complementary distribution. According to Navarro Tomás [1918/1977], the stop allophones [b d g] are found after pause, after a nasal and, in the case of /d/, also after a lateral. Notice that these postconsonantal contexts can be summarized as 'after homorganic sonorants' [Harris, 1969, p. 39], since in Spanish nasals always have the same place of articulation as following consonants and the two segments are homorganic also in the sequence /ld/ → [ld], but not in /lb/ → [lβ] or /lg/ → [lɣ]. Elsewhere, nonstrident continuant allophones are found. Although Navarro Tomás [1918/1977] refers to the continuant allophones as 'fricatives', these realizations are better characterized as approximants [Martínez Celdrán, 1991; Romero, 1995] and this term is generally used in more recent work.

In the traditional view, thus, there are two possible articulatory targets for these three phonemes, stop and approximant, and speakers produce one or the other depending on the preceding segmental context. Since the continuant allophones are found in the majority of positions in the chain (i.e. the 'elsewhere' context), an issue in the synchronic phonological analysis of Spanish is whether the process should be conceptualized as the weakening of underlying stops in most environments [e.g. Harris, 1969], or as the strengthening of underlying continuant segments in certain contexts [e.g. Barlow, 2003], or perhaps in terms of underlyingly unspecified phonemes [e.g. Mascaró, 1984]. Maddieson [2011] classifies Spanish as a language with a voicing contrast involving voiced fricatives/approximants but not stops, since the voiced obstruents are realized as stops only in a minority of environments. Eddington [2011] also represents the phonemes as /β ð ɣ/. Obviously the relative frequency of different allophones is not the only criterion in phonological analysis. Other factors such as the structure of the phonological system of oppositions also need to be taken into account.

Although Navarro Tomás [1918/1977] based his description on Iberian or Peninsular Spanish (i.e., the Spanish of Spain), the same allophonic distribution has been reported as general also in Latin American Spanish, and is often said to characterize 'standard Spanish pronunciation' in pedagogical works [e.g. Hammond, 2001, pp. 191, 197, 201]. Nevertheless, there appear to be geographical varieties of the language with different allophonic distributions. In particular, a number of dialectologists and other researchers have claimed that in certain Central American and Highland Colombian varieties there is a preference for stop realizations in all nonintervocalic contexts, including after all consonants and glides, as in the underlined consonants in the following examples, where in the 'standard' or geographically most widespread distribution of allophones we would expect approximants instead: *las barbas* [sb]-[rb] 'the beards', *el buey volvió* [lb]-[jb]-[lb] 'the ox returned', *es verdad* [sb]-[rd] 'it is true', *la deuda* [wd] 'the debt', *hay* *galgos* [jg]-[lg] ‘there are greyhounds’, *rasgos* [sg] ‘features’ [examples from Canfield, 1962, p. 78; see also Montes Giraldo, 1975; Canfield, 1981, pp. 5–6; Lipski, 1994, pp. 210, 223, 258, 290]. This description, which is based on unquantified auditory perception, was largely confirmed for Costa Rica by Fernandez [1982] in a study of recorded speech from 12 Costa Rican Spanish speakers, where tokens of /b d g/ were classified by the author as either ‘occlusive’ or ‘fricative’ based also apparently on his own auditory impression, but aided in part by visual inspection of spectrograms. Fernandez [1982] provides no information on the methodology that he used to classify tokens. He finds stop allophones in 221 out of 280 tokens where phonemic /b d g/ were preceded by either consonants or glides (79%) [Fernandez, 1982, p. 126]. He thus concludes that there is variation in this respect in Costa Rican Spanish, but with a strong tendency for speakers ‘to choose the occlusive allophone in place of the spirant of the standard language’ [Fernandez, 1982, p. 127] whenever a consonant or glide precedes immediately. In postvocalic position, on the other hand, the opposite tendency, to greatly reduce and vocalize /b d g/, has been reported for (at least part of) the same geographical area, also based on impressionistic observation [Canfield, 1962, p. 78]. Amastae’s [1989] quantified description of the allophony of /b d g/ by preceding context in Honduras Spanish, also based on auditory classification by the author, is largely consistent with Fernandez’s [1982] findings for Costa Rica [see also Amastae, 1995].

The term ‘standard’ used by Fernandez [1982] and other authors implies that other pronunciations are somehow ‘substandard’. This, however, is not the case. Although the existence of dialectal variation in this respect is apparent to the phonetically trained ear, native speakers are generally unaware of it, so that no prestige or stigma is attached to any particular pronunciation. For this reason, in this paper we will use terms like ‘general pattern’ to refer to the geographically more widespread allophonic distribution described by Navarro Tomás [1918/1977].

Although it is possible to make a binary distinction between tokens of /b d g/ with and without full occlusion, it has long been known that, among the latter, one finds a considerable amount of variation in the degree of constriction, from very constricted to fully vocalized [see e.g. Quilis, 1981, p. 224]. Martínez Celdrán and Regueira [2008], based on visual inspection of spectrograms, distinguish among stop, fricative and approximant allophones, and as subcategories of the latter, ‘closed approximant’, ‘open approximant’ and ‘vocalic approximant’. They furthermore notice that the boundaries between allophonic categories can only be fuzzy.

Recent acoustic work has challenged our traditional understanding of the spirantization phenomenon as a choice between two allophones, arguing instead that we have a continuum of realizations of these phonemes regarding their degree of constriction, conditioned primarily by the preceding segment, but also by stress and perhaps other factors [Cole et al., 1999; Soler and Romero, 1999; Ortega-Llebaria, 2004; Eddington, 2011; Simonet et al., 2012].

Simonet et al. [2012], who use several continuous measurements of relative intensity, argue that even among intervocalic tokens of /d/, the height of the preceding vowel conditions in part the degree of constriction of the consonant. They report that in Iberian Spanish /d/ is more constricted after a high vowel than after a mid or low vowel. Effects of specific vowel context were also found for /g/ in Cole et al. [1999] and in Ortega-Llebaria [2004]. Both studies found more constricted realizations of the velar consonant when it was flanked by low vowels than when the flanking vowels where higher. Notice that these results for /g/ are contrary to the findings for /d/ in Simonet et al. [2012]. Ortega-Llebaria [2004] also examined the realization of /b/ in intervocalic position, without finding an effect of vowel height in this case. All of this suggests that contextual effects on lenition may not be uniform across places of articulation.

As mentioned, although the main conditioning factor in the realization of /b d g/ appears to be the preceding segmental context, lexical stress has also been shown to play a role. Ortega-Llebaria [2004] examined the degree of constriction of word-internal intervocalic /b/ and /g/ in bisyllabic forms with stress on either the first or the second syllable. She finds significantly weaker intervocalic /b/ and /g/ realizations immediately after the vowel with lexical stress (e.g. /ˈba**b**a/) than at the onset of the lexically stressed syllable (e.g. /baˈ**b**a/), confirming earlier findings (for /g/) by Cole et al. [1999]. Equivalently, since only these two contexts were examined, intervocalic /b/ and /g/ had stronger realizations when preceding the stressed vowel than after it.

Eddington [2011] used a corpus of unscripted speech and included tokens both inside words and across word boundaries. Regarding stress, he distinguished four contexts: (1) between two unstressed vowels, (2) after a stressed vowel and preceding an unstressed one, (3) after an unstressed vowel and before a stressed vowel, and (4) between two stressed vowels (this fourth context necessarily occurring only across word boundaries). In all stress contexts there can be intervening consonants, since, unlike Cole et al. [1999] and Ortega-Llebaria [2004], he did not limit his study to the intervocalic environment. He finds that /b/ and /d/ have more constricted realizations before the stressed vowel (contexts 3 and 4) than in other contexts. For /g/, he finds significantly more constricted realizations only for the context where both the preceding and the following vowel are stressed (context 4), without any significant differences among the other three contexts.

In general, and putting all findings of the different studies together, the effect of stress that has been reported for Spanish /b d g/ appears to perhaps mirror the more readily observable situation in American English where /t/ is lenited to a flap after the stress, as in *ˈa**t**om*, *poˈta**t**o* and also preceding the stressed syllable when surrounded by unstressed vowels, as in ***att**iˈtudinal,* but not at the onset of the lexically stressed syllable, as in *aˈ**t**omic, attiˈ**t**udinal, poˈ**t**ato*.

Most previous acoustic studies of Spanish spirantization focus on Peninsular Spanish, although Ortega-Llebaria's [2004] 5 subjects spoke varieties of Caribbean Spanish and Colantoni and Marinescu [2010] examined Argentinean Spanish. Eddington [2011] included data from 8 participants from both Spain and Latin America, without separating by dialect. To our knowledge there are no previous acoustic studies of spirantization in Costa Rican Spanish or in other varieties spoken in Central America and Highland Colombia where, as mentioned, dialectological description has indicated a frequent occurrence of stop allophones after all consonants and glides.

A goal of this paper is to determine whether Costa Rican Spanish, in fact, significantly differs from other dialects in its allophony of /b d g/ when a continuous acoustic measure of spirantization is adopted, instead of the binary allophonic classification used by Fernandez [1982]. In this respect it is important to note that both Fernandez [1982] and other authors who have noted a difference in the implementation of spirantization in varieties of Central American and Highland Colombian, when compared with Peninsular and other dialects, speak of variation and tendencies, rather than of categorical complementary distribution of allophones. Fernandez [1982] does not provide any information on the methodology he used to classify tokens as 'occlusive' or 'fricative' or on any difficulties in classifying tokens. Going beyond impressionistic description thus seems important for obtaining a more accurate view of the facts.

Here we report on a large-scale acoustic analysis of /b d g/ in lenition contexts in the Spanish variety of San José, Costa Rica, establishing a comparison with that of Madrid, Spain.

The existence of differences in the implementation of the allophony of voiced plosives in different Spanish dialects naturally raises the question of what the historical reason for this interdialectal variation may be. In its origin, Spanish spirantization must derive from the conventionalization of the phonetic reduction or lenition of plosives [Romero, 1995; Lavoie, 2001]. Spirantization or oral leakage during the production of a voiced oral stop facilitates vocal fold vibration during the constriction [Solé et al., 2009]. That is, spirantization may be a strategy to maintain voicing. As already mentioned, continuant realizations of /b d g/ can in fact be found as an occasional, casual speech phenomenon in many languages. Once a phonetic reduction has been conventionalized across styles in the speech community, however, further changes are less predictable. Stronger variants may indeed increase in their frequency and spread to new contexts. Thus, in Rome Italian intervocalic /b/ is realized as a geminate, against the universal tendency to avoid long voiced plosives. The ultimate cause of this phenomenon is that the sound change /b/ > /v/ in intervocalic position left the geminate (which had not been affected by lenition) as the only available articulation for speakers when *b* was reintroduced in learned words and word-initial alternations were restructured [Bertinetto and Loporcaro, 2005; Loporcaro, 2009; Hualde and Nadeu, 2011]. Also, and directly related to the topic of this paper, in Judeo-Spanish the spirantization of /b d g/ has arguably undergone regression with respect to 15th century Spanish [Quintana, 2006; Hualde, in press]. Fernandez [1982] suggests in fact that in Costa Rican Spanish as well we have a sound change in progress that is tending towards increasing the contexts where voiced plosive allophones are typically found. Our view on this matter is somewhat more nuanced, as we will explain in the 'Discussion' section.

In the following sections we describe our experimental methodology and results. This is followed by discussion of the possible historical explanation for the different state of affairs that we find in Costa Rica and Spain regarding allophonic preferences.

Methods

Participants

For this study we have collected and analyzed speech data from 13 subjects, 10 speakers of Costa Rican Spanish and 3 speakers of Madrid Spanish. The Costa Rican speakers were all from the San José metropolitan area and were recorded in San José. They are 5 men and 5 women ranging from 26 to 47 years of age at the time of participation in the study. All 10 speakers had postsecondary education.

Madrid Spanish was used as a point of comparison, taken to be representative of those dialects that have been described as presenting the 'standard' or general distribution of allophones of /b d g/. We thus had a smaller group of speakers of this dialect, 2 men and 1 woman. What justifies the smaller number of speakers of Madrid Spanish is that this geographical variety is not the focus of the study, but, rather, a control. The 3 Madrid speakers were graduate students at the University of Illinois at Urbana-Champaign at the time of the recording. Although they spoke English reasonably well, they had grown up as monolingual Spanish speakers and this was clearly their dominant language, which they used every day. They had lived in Spain all their lives before moving to North America for graduate education. They had been living in the United States for about 2 or 3 years and returned to Spain in the summer.

Data Collection Tasks

Subjects were asked to participate in four different tasks, intended to provide different degrees of formality [Labov, 1972]. Following findings and assumptions in variationist sociolinguistics, we reasoned that the different tasks would encourage speakers to pay more or less attention to their phonetic productions, thus presumably triggering variation in the degree of lenition or constriction of the target sounds across tasks. Two tasks involved unscripted speech and the other two, read speech. By hypothesis, we anticipated that unscripted speech would divert the attention of the participants paid to their own speech productions to some extent while reading out loud would encourage speakers to produce more formal variants of sounds, that is, to monitor their speech productions more closely [Labov, 1972].

The first task was a sociolinguistic interview intended to elicit spontaneous speech. Here we do not report on data obtained during the unscripted interview (task 1) because it did not yield balanced data sets (see below) [see Carrasco, 2008].

The second task was an adaptation of the picture-naming task, where the subject was shown a picture of an object on a computer monitor, with its corresponding orthographic representation displayed on the lower left-hand side of the screen. The task we used was more than a simple picture-naming task: speakers were asked to formulate three complete sentences using this word, so they used these words creatively. Participants were asked to form sentences in which the name of the depicted object would appear in the subject of the sentence, and thus towards the beginning of the sentence, rather than in the predicate. Even if participants read the orthographic representation of the objects they were asked to describe, we reasoned that, since they were prompted to elicit a spontaneous response to each image, this task would divert some attention paid to speech, at least relative to other tasks such as the following ones. There were a total of 80 depicted objects, presented to subjects in pseudorandom order. Materials included words such as: *una bata* /aba/ 'a robe', *una dalia* /ada/ 'a dahlia', *una gata* /aga/ 'a cat, fem.', *una aldaba* /lda/ 'a door knocker', *una corbata* /rba/ 'a necktie' (see below).

In a third task, participants read a pseudorandomized list of meaningful sentences three separate times. Sentences were thus presented in three different blocks, each block containing one presentation of each sentence, with the three blocks containing the same sentences in a different pseudorandom order. Each carrier sentence included one of the same words as those that had been used in task 2. This task presumably encouraged a more formal speech style than the previous task because here subjects are not prompted to elicit any spontaneous responses: they are given all the materials and are simply instructed to read the materials. Therefore, it is expected that speakers will monitor their productions more closely than in a task in which they need to create their own sentences. Materials included sentences such as: *una corbata es una prenda de vestir* 'a necktie is an article of garment', containing the sequence /rba/, *una bata es una prenda para estar en casa* 'a robe is an item of clothing that one uses inside the house', which contains the sequence /aba/, etc. (see below).

Finally, in a fourth task, subjects were asked to read a pseudorandomized word list three separate times, i.e. in three different pseudorandomized blocks. The words in this task were the same as those in tasks 2 and 3. (See the 'Appendix', where we list the words used in all three tasks.) This task differs from the previous one in that target words are presented in isolation. This possibly prompts subjects to produce a citation form of each word, in narrow focus, which may also alter speech productions. This is the reasoning offered in Labov [1972] and subsequent variationist research. In sum, we were able to collect productions of the same words in three different tasks, intended to correlate with different degrees of conscious attention to the pronunciation of words.

Materials

The materials (target words) were balanced for (1) place of articulation of the target consonant (/b/, /d/, /g/), (2) position in word (word-initial vs. word-medial), (3) stress position (target segment at the onset of stressed vs. unstressed syllable) and (4) preceding segment (vowel /a/, glide /j/, liquids /r/, /l/, fricative /s/). The segment following the target consonant was always the vowel /a/. (See the 'Appendix', where we list the words used in all three tasks.) The analysis of the variation along the lenited-constricted continuum of target consonants was to be analyzed as a function of these four factors. The inclusion of these factors is motivated below.

First, since we were interested in the three phonemic voiced obstruents, we collected data corresponding to /b/, /d/ and /g/. Since degree of lenition may differ for these three consonants, possibly because of articulatory or aerodynamic factors, the three consonants were examined separately. On the other hand, previous description of Costa Rican/Central America Spanish did not allow us to formulate any clear hypothesis regarding the possible existence of a hierarchy of the degree of weakening among the three voiced obstruents involved.

Secondly, the possibility exists that lenition differs as a function of the position of consonants within their corresponding word. For instance, in the evolution from Latin to Old Spanish, sound change (phonologized lenition) affected word-medial consonants differently than word-initial ones; that is, Latin *illa porta* 'the door' became Spanish *la puerta* (p– > p–) while Latin *cupa* 'wine vat' became Spanish *cuba* (–p– > –b–). The causes for this differential evolution have received some attention in the literature [see e.g. Weinrich, 1958; Cravens, 2002; Hualde et al., 2011b]. Since we could not exclude a priori that lenition of /b d g/ in our data would differ as a function of word position, the decision was made to explore this factor in our analyses.

Thirdly, in a landmark study, Cho and McQueen [2005, see also references therein] examined the phonetic characteristics of several Dutch consonants in different prosodic positions. They manipulated lexical stress, the presence of a phrasal accent and the presence of a prosodic boundary. These authors found robust effects of what they call 'prosodic strengthening' on the acoustics of consonants appearing in the following positions: lexically stressed syllables, in the presence of a phrasal accent and in the presence of a prosodic boundary. Therefore, it is a reasonable hypothesis that lexical stress affects consonant lenition (inducing fortition, which could be considered a type of 'prosodic strengthening'). We conceive lexical stress as a property of the syllable (rather than the vowel), following the results in Cho and McQueen [2005] among many others, and considered that a consonant appeared in a lexically stressed position if it was found at the onset of a lexically stressed syllable, i.e. /b/ is considered 'stressed' in *la b̲ata* /laˈbata/ 'the robe' and 'unstressed' in *la b̲atata* /labaˈtata/ 'the sweet potato'. This assumption is in line with findings reported in Browman and Goldstein [1988, 1995], among others, which discuss evidence suggesting that onset consonants are carefully timed with respect to (and coarticulated with) nuclear consonants in syllables rather than with preceding vowels. As mentioned in the 'Introduction', previous work on Spanish spirantization has found less lenited consonants at the onset of stressed syllables. Our unstressed condition contains consonants in syllables both preceding the lexically stressed one, as in *la b̲at*[ˈa]*ta*, and following it, as in *c*[ˈe]*ib̲a* (see 'Appendix'). Although our decision to put these two unstressed contexts together was due primarily to the difficulty of finding lexical items for all environments tested, we feel justified in this decision, since both of these contexts allow weakening in processes such as flapping in American English, as discussed in the 'Introduction'.

Fourthly, the crucial manipulation in our study was that of preceding context. As explained in the 'Introduction', the traditional phonological analysis of Spanish spirantization depends solely on the preceding context. The existing descriptions of the two dialects examined here crucially differ in some of the key contexts manipulated in our study. Target consonants were preceded by the low vowel /a/ (e.g. *la b̲ata* /aˈba/ 'the robe'), the glide /j/ (e.g. *muy b̲ajo* /jˈba/ 'very low'), the liquids /r/ (e.g. *ser b̲ajo* /rˈba/ 'to be short'), and /l/ (e.g. *el b̲áculo* /lˈba/ 'the stick') and the fricative /s/ (e.g. *los b̲ates* /sˈba/ 'the baseball bats'). As mentioned in the 'Introduction', these are all contexts that, in the traditional description of general Spanish pronunciation, are claimed to condition continuant allophones of /b d g/, except for the sequence /ld/, which is said to condition the noncontinuant allophone of /d/. We did not include the context following a nasal, which, in the traditional understanding of the facts, uniformly conditions stop allophones of /b d g/. Although we compare the acoustics of target consonants under the influence of the preceding contexts, in all cases we examine the acoustic transitions of target consonants into the following vowel, which is always /a/, rather than the preceding one (see below). That is, V2 is taken as reference for measuring relative energy. Vowel quality was controlled because, as mentioned in the 'Introduction', previous studies have found an effect of vowel quality, which, furthermore, may be different for each of the three places of articulation involved. We chose the most open vowel as a constant following context and also as a preceding context for intervocalic tokens.

As mentioned above, data from task 1 were discarded from further analyses due to the fact that it was not possible to select balanced numbers of observations for all factor levels that were readily comparable to data from the other three tasks. We decided that it was preferable not to include balanced and unbalanced subsets of data in the same statistical analysis. Thus, only data from tasks 2, 3 and 4, which are balanced for all relevant factors, are discussed here. We leave the analysis of the spontaneous data from task 1 for a possible future follow-up study.

Each subject produced up to 60 different target consonants per task, 3 times (60 segments × 3 iterations × 3 tasks = 540 tokens per speaker). There was one single lexical item representing each

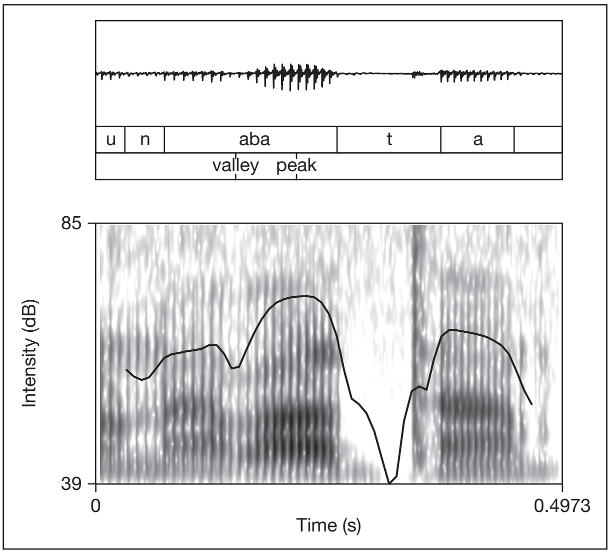

Fig. 1. Sound wave, spectrogram and intensity contour of the phrase *una bata* /aˈba/ 'a robe' produced by a male speaker from Madrid, Spain. The target intensity valley and peak used for our intensity-based metric are marked. (Consonants and vowels were not segmented in our analysis.)

combination. Therefore, the dataset had the following structure: 3 places of articulation × 5 preceding contexts × 2 stress configurations × 2 word positions × 3 tasks × 13 subjects. This resulted in a data set with a theoretical ceiling of 7,020 tokens.

Recordings

The productions of the 13 participants were recorded using professional equipment: a solid-state digital recorder (Marantz PMD660) connected to a head-worn, low-impedance, dynamic microphone (Shure SM10A). The signal was sampled at 44.1 kHz and with 16-bit quantization. Speakers from Costa Rica were recorded in San José, Costa Rica, each in a quiet room, either in their home or workplace. Speakers from Madrid were recorded in the Illinois Phonetics and Phonology Laboratory, at the University of Illinois at Urbana-Champaign. In Illinois we were able to use a sound-attenuated booth.

Acoustic and Statistical Analyses

The acoustic analysis of the data was carried out with Praat [Boersma, 2001]. For each target segment we manually placed two marks: (1) one at the point of minimum intensity within the consonant /b/, /d/ or /g/ (when an intensity dip was observable) and (2) another one at the point of maximum intensity during the following vowel (always /a/), as reflected by the intensity curve provided by Praat with default settings [see Praat manual]. The settings were as follows: minimum pitch was 100 Hz and time step was set to 0, which means that it was calculated as one quarter of the effective window length. The mean was subtracted. The first author, using synchronized displays of the intensity contour, the spectrogram and the sound wave, carried out the marking of the two acoustic time points in each target segment by hand.

Figures 1 through to 6 display the sound wave, spectrogram and intensity contour of several Spanish phrases in which /b/ appears in different phonetic contexts: /aˈba/, /jˈba/ and /rˈba/. Figures 1, 3 and 5 show data from Madrid, Spain, while figures 2, 4 and 6 show comparable data from San José, Costa Rica. The figures also show the location of the valley (or intensity minimum) and the peak (or intensity maximum) in each sample observation.

Subsequent statistical analysis is based on the intensity ratio resulting from dividing the values in decibels (min/max) at the two points manually marked for each token. In all cases, except when consonant deletion has occurred, a rise in intensity is expected to take place. Taking this intensity ratio as an indication of degree of constriction, a ratio closer to '1' will indicate a more open vowel-like production of the consonant (the intensity of the two landmarks is similar), and a ratio closer to '0' will

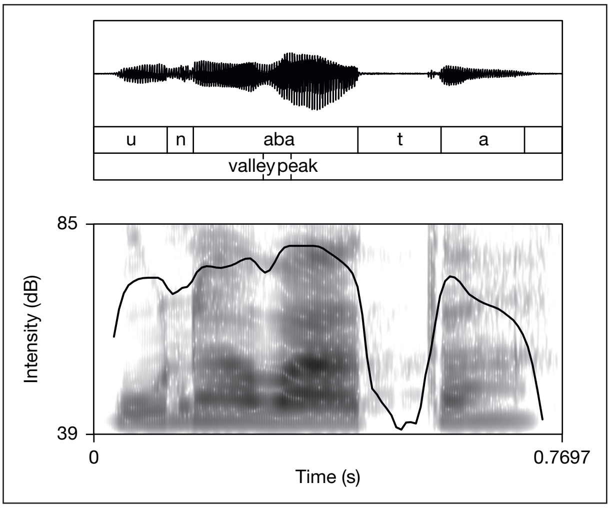

Fig. 2. Sound wave, spectrogram and intensity contour of the phrase *una bata* /aˈba/ 'a robe' produced by a female speaker from San José, Costa Rica. The target intensity valley and peak used for our intensity-based metric are marked. (Consonants and vowels were not segmented in our analysis.)

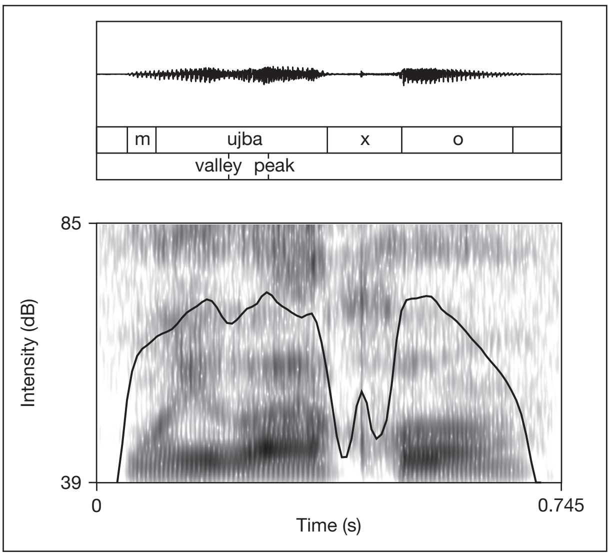

Fig. 3. Sound wave, spectrogram and intensity contour of the phrase *muy bajo* /jˈba/ 'very low' uttered by a male speaker from Madrid, Spain. The target intensity valley and peak used for our intensity-based metric are marked. (Consonants and vowels were not segmented in our analysis.)

indicate a more stop-like realization (the intensity of the two landmarks is very different, with that of the first landmark being much lower than that of the second). Productions with no clear intensity dip are evident in ratio values equal to or greater than 1. These are considered fully vowel-like productions, that is, deleted consonants. Figure 7 illustrates our method for computing our intensity-based metric: valley (dB) divided by peak (dB).

Relative intensity (calculated either as a difference or as a ratio) has been used as an acoustic correlate of consonantal constriction for Spanish /b d g/ in several other studies [Cole et al., 1999; Soler and Romero, 1999; Ortega-Llebaria, 2004; Colantoni and Marinescu, 2010; Eddington, 2011]. In Hualde et al. [2010, 2011b], Hualde and Nadeu [2011] and Simonet et al. [2012], two or three measurements, including intensity difference between the consonant and the following vowel, are

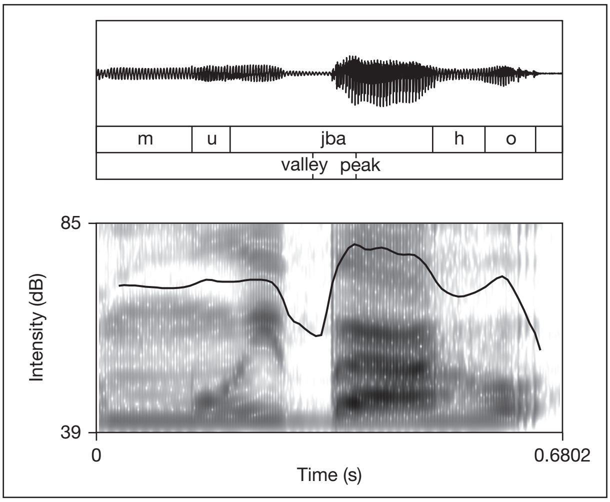

Fig. 4. Sound wave, spectrogram and intensity contour of the phrase *muy bajo* /jˈba/ 'very low' produced by a female speaker from San José, Costa Rica. The target intensity valley and peak used for our intensity-based metric are marked. (Consonants and vowels were not segmented in our analysis.)

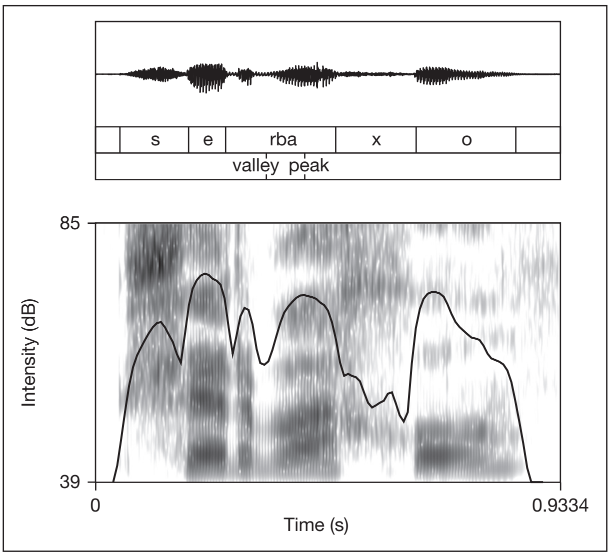

Fig. 5. Sound wave, spectrogram and intensity contour of the phrase *ser bajo* /ɾˈba/ 'being short' produced by a male speaker from Madrid, Spain. The target intensity valley and peak used for our intensity-based metric are marked. (Consonants and vowels were not segmented in our analysis.)

compared with each other in several corpora of voiced and voiceless obstruents in Spanish, Catalan and Italian. Parrell [2010] compared, for Spanish labial consonants, several acoustic indexes of the constriction-lenition degree with articulatory data collected with electromagnetic articulography. Although several of the indexes resulted in reasonably good correlations, Parrell [2010] argues that intensity ratio, the index we use here, is the one that most strongly correlates with articulatory data, at least for labials.

A possible drawback of our measurement is that stress effects need to be interpreted with caution since these effects on our ratio metric may be due to the hypothetically higher intensity values of stressed vowels over unstressed ones, rather than to constriction differences in the consonants being compared.

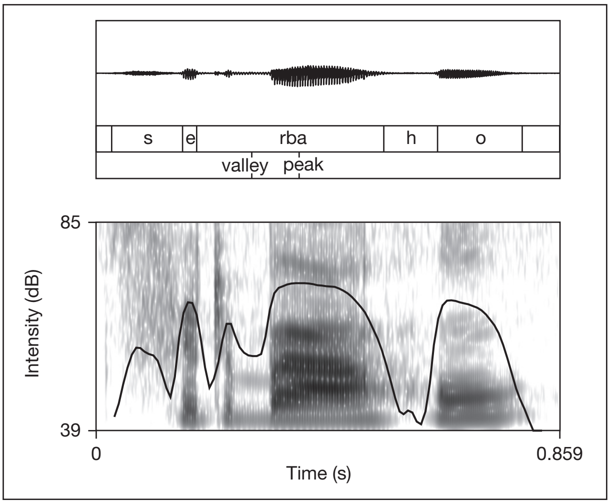

Fig. 6. Sound wave, spectrogram and intensity contour of the phrase *ser bajo* /rˈba/ 'being short' produced by a female speaker from San José, Costa Rica. The target intensity valley and peak used for our intensity-based metric are marked. (Consonants and vowels were not segmented in our analysis.)

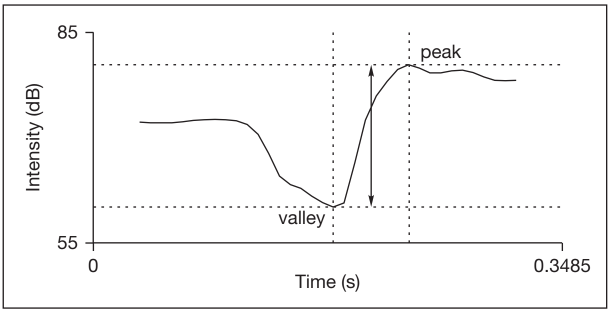

Fig. 7. Graphical display of our intensity ratio metric corresponding, in this case, to the phrase *muy bajo* /jˈba/ 'very low' produced by a female Costa Rican speaker. The 'valley' is the lowest intensity value in the region of the target consonant. The 'peak' is the highest intensity value in the region of the following vowel. Only intensity values (i.e., no segmental boundaries) were used in our metric. Intensity ratio = valley (dB)/peak (dB). In this example, 80.38 dB/60.12 dB = 0.7478.

We wish to highlight that exact positioning of segmental boundaries is not of crucial relevance in our analyses. Although we marked intensity valleys and peaks by hand, we only did so in the case valleys and peaks were indeed observable. In all other cases we simply excluded the tokens from further analyses. (Notice that this was also insured with the automatic procedure that discarded all intensity ratios above 1). At any rate, the time difference or time location of the landmarks does not enter the calculation of the constriction/lenition index at any point in our analysis. We make no use of duration measurements. Note also that consonants and vowels were not hand segmented in our analyses.

In all, over 7,020 tokens were collected, since in task 2 some subjects produced more than 3 iterations per consonant. Several data-trimming procedures were applied to the data before submitting them to statistical analysis. (1) Iterations of the same word by the same speaker in the same task exceeding 3, in case they were produced (i.e. iterations 4 and above), were discarded (n = 58), bringing back the data set to the anticipated ceiling of 7,020 tokens. (2) Tokens with ratio values equal or larger than 1 were excluded (n = 105, 1.5%). In these tokens, there was no clear intensity dip during the consonant; in other words, we found no evidence of a consonantal gesture in the acoustic analysis of intensity of these tokens. We made the decision to exclude these tokens for two reasons, one of them being that some scholars may prefer for deletion cases to be treated qualitatively differently from cases of gestural reduction such as the ones we examine. Most importantly, however, these cases were excluded because they are not amenable to arcsine transformation (see below). These procedures resulted in a data set consisting of 6,915 observations (Costa Rica, n = 5,315; Spain, n = 1,600). All 6,915 tokens presented a rise in the intensity trajectory from the target consonant to the following vowel, and thus showed some evidence of the presence of a consonantal gesture, even if in some cases it may have been very weakened.

The dependent variable was inspected for normality as follows: We visualized quantile-quantile plots and calculated correlations between theoretical quantiles (theoretical normal distributions) and observed distributions [see e.g. Johnson, 2008, pp. 15–24]. Furthermore, ratio values were arcsine-transformed with the formula in (1).

(1) $2/\pi \times \text{arcsine} (\sqrt{x})$

Proportion data tend to be positively or negatively skewed, and thus not normal. Arcsine transformation spreads out skewed data so they approach normality [Johnson, 2008, p. 23]. This is the main reason why ratio values greater than 1 were excluded (see above), i.e. these values may not be arcsine-transformed. However, identical tests for normality did not reveal any increase in normality of distribution for arcsine-transformed ratio values with respect to nontransformed values. Thus, ratio values as originally extracted from Praat were primarily used for subsequent statistical modeling, even though complementary tests with arcsine-transformed data were also carried out. For Costa Rica, the correlation between theoretical and observed quantiles was $r = 0.996$ (arcsine-transformed, $r = 0.978$). For Spain, the correlation was $r = 0.994$ (arcsine-transformed, $r = 0.992$). Analyses of by-subject distributions also resulted in high correlation values between theoretical and observed quantiles. We did not submit our data to any further normality tests. The data, which were divided into two main separate data sets as a function of dialect (Costa Rica, Spain), were considered as 'normal' as behavioral data tend to be, and thus amenable to submission to parametric tests.

The effects of several fixed and random factors were tested with a series of linear mixed-effects models further submitted to ANOVA summaries. The models were carried out with the LME4 package implemented in the computational environment R [Bates and Maechler, 2010]. The most important contribution of this modeling technique for our purposes is that it allows for the declaration of more than one random variable. Random factors in our models were 'speaker' (10 individuals for Costa Rica, 3 for Spain) and 'word iteration' (1, 2, 3). According to Johnson [2008, p. 233], 'mixed-effects modeling is particularly appropriate for data with uneven numbers of observations in the random effects because it uses restricted maximum likelihood procedures rather than least-squares estimation'. Fixed predictors were: (1) place of articulation: /b/, /d/, /g/; (2) lexical position: word-initial (but phrase-medial) versus word-medial; (3) preceding segment: /a/, /j/, /r/, /l/, /s/; (4) lexical stress: stressed versus unstressed syllable; (5) task: picture description (task 2) versus reading of sentences (task 3) versus reading of words (task 4).

Results

Madrid, Spain

The intensity ratio values were submitted to a linear mixed-effects model as response, the two mentioned random intercepts and the following fixed factors: place of articulation, position, stress, preceding segment and task. There were 1,600 observations in the Spain data subset: 540 from speaker 1, 537 from speaker 2, and 523 from speaker 3. We were concerned with the fixed effects plus the potential interactions between place of articulation and the other four fixed factors. The model yielded significant effects of all predictors except word position. Therefore, we refitted the model without including word position as a predictor. The resulting model yielded significant effects of place of articulation [$F(2, 1,576) = 58.6$, $p < 0.001$], stress [$F(1, 1,579) = 407.9$, $p < 0.001$], preceding segment [$F(4, 1,579) = 137.6$, $p < 0.001$] and task [F2, 1,540) = 40.7, $p < 0.001$]. Place of articulation significantly interacted with preceding segment [F(8, 1,576) = 10.7, $p < 0.001$]. No other interactions reached significance. This suggests that all three phonemes (/b d g/) are similarly affected by factors such as stress and task (style), but are differently affected by the preceding segment. Subsequently, we explored the effects of the fixed predictors separately.

When discussing the results of regression models, we provide the estimate (or β value) of the intercept (or level with which all other levels are contrasted), the estimate of the contrasted levels (or β value of the level, which is the difference between the estimated mean of the intercept and the estimated mean of the corresponding level), and the t statistic of the contrast. For our purposes t values lower than –2 and greater than 2 are considered to represent a statistically significant difference, i.e. this is our alpha level. For instance, if the intercept has a β value of 0.999 and one of the levels has a β value of –0.010, this means that the estimated mean of the contrasted level is 0.999 – 0.010 = 0.989.

The coefficients (β) of the main regression model, in which (stressed, word-initial) /b/ (in task 2) was taken as the intercept ($\beta = 0.906$), showed /b/ to be significantly more lenited than /g/ ($\beta = –0.034$, $t = –4.75$) while /d/ was not found to differ from /b/ ($\beta = 0.006$, $t = 0.90$). However, as the intercept does not include all instances of /b/, the statistical model does not allow us to draw general conclusions regarding differences in constriction degree among the three consonants across all contexts. Also, the model, in which stressed consonants were taken as the intercept ($\beta = 0.906$), showed unstressed consonants to be significantly more lenited than stressed ones ($\beta = 0.04$, $t = 11.09$). Finally, the model, in which task 2 was taken as the intercept ($\beta = 0.906$), showed that consonants in tasks 2 and 3 did not differ from each other ($\beta = 0.002$, $t = 0.48$) while consonants in task 4 were significantly more constricted than consonants in task 2 ($\beta = –0.016$, $t = –3.77$). In other words, reading isolated words resulted in more constricted voiced obstruents than reading them in sentences or using them in spontaneous sentences.

Since there were significant interactions between place of articulation and preceding segment, and since preceding segment has so many levels, we explored these interactions with data subsets. In order to examine the effects of the preceding segment on the three consonants separately, we submitted each data subset (one subset per consonant) to three independent linear mixed-effects regression models. The parameters of the models were as follows: intensity ratio as response, speaker and iteration as random intercepts and preceding segment as a single fixed predictor. In this part of the analysis, we were only concerned with examining the effects of the preceding segment on the target consonants. The results of the models are reported in table 1, which reports on the results of a total of nine mixed-effects models, three per consonant data subset. This was so because regression models allow for the inspection of differences only between one level (the intercept) and all others in a pairwise manner. Therefore, in order to be able to inspect other pairwise contrasts, two other intercepts were selected and the models were refitted (see below).

Figure 8 displays box plots of intensity ratios as a function of preceding context for the three consonants separately. Black circles in the boxes represent the mean of the entire distribution. The boxes display the interquartile range, i.e. observations between the 25th and the 75th percentiles. Whiskers extend to the most extreme of the observations lying no further away than 0.5 the length of the box. Observations beyond this point, outliers, are marked as circles.

Table 1. Madrid, Spain: regression coefficients (β) and t statistics returned by three independent linear mixed-effects regression models fitted to /b/, /d/ and /g/ data sets with intensity ratio as response, preceding segment as fixed factor and speaker and iteration as random intercepts

	/b/		/d/		/g/	
	β	t	β	t	β	t
Intercept /a/	0.921		0.923		0.889	
/j/	–0.033	–4.93	–0.011	NS	–0.018	–2.94
/l/	–0.074	–11.13	–0.046	–6.97	–0.022	–3.63
/r/	–0.063	–9.46	–0.032	–4.77	–0.013	–2.10
/s/	–0.103	–15.52	–0.065	–9.85	–0.049	–7.99
Intercept /j/	0.888		0.911		0.871	
/a/	0.033	4.93	0.011	NS	0.018	2.94
/r/	–0.030	–4.56	–0.020	–3.03	0.005	NS
/l/	–0.041	–6.23	–0.034	–5.23	–0.004	NS
/s/	–0.070	–10.65	–0.053	–8.12	–0.031	–5.04
Intercept /r/	0.857		0.891		0.876	
/j/	0.030	4.56	0.020	3.03	–0.005	NS
/a/	0.063	9.46	0.032	4.77	0.013	2.10
/l/	–0.010	NS	–0.014	–2.17	–0.009	NS
/s/	–0.040	–6.08	–0.033	–5.04	–0.036	–5.86

The three models were refitted 3 times each with a different intercept: /a/, /j/, /r/.

Regarding /b/ (table 1), the model reveals significant pairwise differences between consonants preceded by /a/, which is the intercept, and consonants in all other contexts. Specifically, /b/ tokens are more lenited when following /a/ (and thus in an /aba/ context) than when following any other sounds. The model was refitted twice, with two different intercepts, /j/ and /r/. The first refitted model showed differences between /b/ tokens preceded by /j/ and those preceded by /r/, /l/ or /s/, in addition to the one that had already been found between /a/ and /j/. Specifically, /b/ is more lenited when following /j/ than when following any of the three consonants considered in the study. Finally, the model in which /r/ was taken as the intercept yielded an additional significant difference between /r/ and /s/ contexts but not between /r/ and /l/ contexts. In other words, /b/ is more lenited when preceded by /r/ than when preceded by /s/, at least according to our acoustic index of lenition. In sum, a gradient scale from more lenited to more constricted /b/ was found in the following order: /a–/ > /j–/ > /r– l–/ > /s–/.

Regarding /d/ (table 1), we found that this consonant was more lenited in the context of /a/ than in the context of /r/, /l/ or /s/, but not when /d/ followed /j/. Additionally, the first refitted model yielded significant differences between /d/ tokens preceded by /j/ and those preceded by /r/, /l/ or /s/; that is, /d/ was more constricted when preceded by the three consonants we examined than when preceded by a low vowel or a glide. Finally, the model in which /r/ was taken as the intercept showed that /d/ is more lenited when preceded by /r/ than when preceded by /l/ or /s/. In sum, constriction in /d/ was gradually strengthened in the following order: /a–/ > /j–/ > /r–/ > /l– s–/. (Notice that we did not test for potential differences between /l/ and /s/ contexts, though these may exist.)

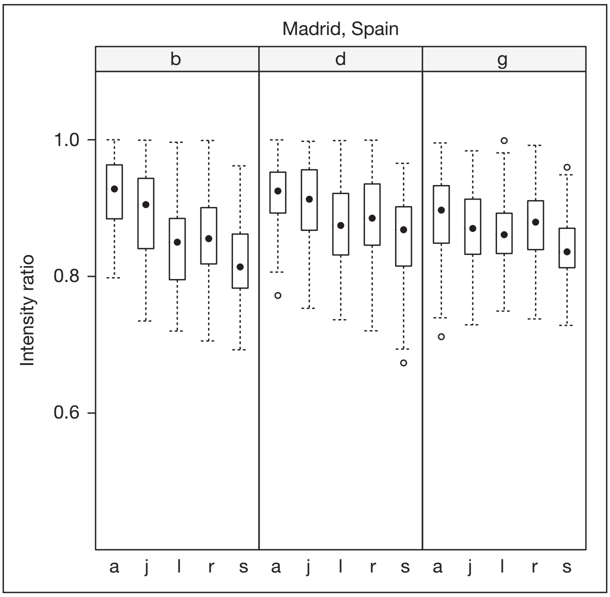

Fig. 8. Madrid, Spain. Box plots of intensity ratio values as a function of place of articulation (/b d g/) and preceding context (/a j l r s/).

Regarding /g/ (table 1), we found more lenited consonants in /a/ contexts than in any of the other four preceding contexts. The refitted model with /j/ as the intercept suggested additional significant differences between /g/ tokens preceded by /j/ and those preceded by /s/, but not with those preceded by /r/ or /l/. Finally, the model in which /r/ was the intercept revealed a significant difference in intensity ratio between /g/ preceded by /r/ and that preceded by /s/, but not between contexts /r/ and /l/. In sum, a gradient continuum was found in the following order: /a–/ > /j– r– l–/ > /s–/.

To sum up, focusing on the most important results, the statistical analysis of the Madrid Spanish data lead to the following findings: (1) There is no statistical difference between word-initial (but phrase-medial) tokens of /b d g/ and word-medial tokens. (2) The degree of constriction of the target consonants – as reflected by our acoustic metric – depends on that of the preceding segment; the most open sounds are found after /a/, and the most constricted ones after /s/. For /d/ we find a continuum of constriction as a function of the preceding segment, with every preceding context affecting /d/ slightly but significantly. This is also true for /b/, except that no difference was found between the contexts after /r/ and after /l/. Finally, for /g/ only three contexts triggered statistically significant differences, namely, after /a/ (most lenited), after /s/ (most constricted) and all others (/j r l/). (3) The intensity ratio is greater in stressed than in unstressed syllables. (4) Our speakers produced more constricted consonants when reading words in isolation than when performing other tasks where words were placed in a meaningful context.

San José, Costa Rica

We submitted the intensity ratio values to a linear mixed-effects model as response, with place of articulation, position, stress, preceding segment and task as fixed factors and speaker and iteration as random intercepts. Due to the nature of our main question, we were exclusively concerned with the fixed effects and with any interactions between place of articulation and preceding segment. The model yielded significant effects of all five fixed factors: place of articulation [F(2, 5,296) = 5.65, p < 0.001], stress [F(1, 5,296) = 1,272.1, p < 0.001], preceding segment [F(4, 5,296) = 1,002.01, p < 0.001], task [F(2, 5,296) = 58.03, p < 0.001], and position [F(1, 5,296) = 39.39, p < 0.001]. Place of articulation significantly interacted with preceding segment [F(8, 5,296) = 90.53, p < 0.001].

The fixed effects of place of articulation were due to (word-initial stressed) /b/ (in task 2; the intercept, β = 0.896) being more lenited that /d/ (β = –0.024, t = –5.45) and /g/ (β = –0.105, t = –24.14). Once again, however, as the intercept does not include all instances of /b/, the statistical model does not allow us to draw general conclusions regarding differences in constriction degree among the three consonants across all contexts. The model also showed that unstressed consonants (β = 0.059, t = 37.49) were more lenited than stressed ones (the intercept, β = 0.896). Regarding the effects of position, it was found that word-medial consonants (β = 0.010, t = 6.38) were significantly more lenited than word-initial ones (the intercept, β = 0.896). Finally, with respect to task, the model selected task 2 as the intercept (β = 0.896) and showed that task 3 triggered a slight but significant weakening in constriction degree (β = 0.006, t = 3.16), while task 4 triggered a significant fortition (β = –0.014, t = –7.37). The effects of preceding segment were inspected for the three places of articulation separately due to the interactions revealed by the main model.

In order to explore the interactions between place of articulation and preceding segment, we fitted three separate mixed-effects regression models to the /b/, /d/ and /g/ data and then refitted them twice each with a different ordering of contrasts. The models are reported in table 2. See also figure 9 for a box plot display of the intensity ratio distributions as a function of place of articulation and preceding segment.

Regarding /b/ (n = 1,773), the model for which /a/ contexts were taken as the intercept suggested that all other contexts triggered significantly more constricted realizations of /b/ than the /a/ context. The model in which /j/ was the intercept further revealed a difference in constriction degree between this context and the /s/ context. Interestingly, no significant difference was found between /b/ preceded by /j/ and /b/ preceded by /l/, and only a marginally significant one between the intercept and the /r/ context. Additionally, the model in which /r/ was the intercept yielded a significant difference between the /r/ context and the /s/ context, but not between /b/ preceded by /r/ and /b/ preceded by /l/. In sum, the statistical analyses suggested the following scale, from more lenited to more constricted: /a–/ > /j– r– l–/ > /s–/. Importantly, the difference between /b/ in the context of /a/ and all other contexts was much larger (see β values in table 2) than that between any of the members of the second group (/j r l/) and /s/ (see also fig. 9).

Regarding /d/ (n = 1,745), the first model also showed that /d/ preceded by /a/ was significantly more lenited than when this consonant was preceded by any of the other sounds (/j r l s/). The refitted model, exploring /j/ as the intercept, further revealed that /d/ was more lenited when preceded by /j/ than when preceded by /s/. However, this consonant was significantly more constricted when preceded by /j/ than when preceded by either /r/ or /l/, although the difference between the /j/ and the /r/ contexts was only marginal. Finally, the model in which /r/ was taken as the intercept further showed that this context triggered more lenited consonants than the /s/ context. Moreover, /d/ was more lenited in this context that in the context of /l/, although the difference was,

Table 2. San José, Costa Rica: regression coefficients (β) and t statistics returned by three independent linear mixed-effects regression models fitted to /b/, /d/ and /g/ data sets with intensity ratio as response, preceding segment as fixed factor and speaker and iteration as random intercepts

	/b/		/d/		/g/	
	β	t	β	t	β	t
Intercept /a/	0.925		0.900		0.822	
/j/	–0.172	–40.13	–0.143	–27.67	–0.074	–14.91
/l/	–0.167	–38.86	–0.120	–23.22	–0.031	–6.31
/r/	–0.160	–37.38	–0.131	–25.30	–0.044	–8.94
/s/	–0.196	–45.63	–0.166	–32.07	–0.069	–14.03
Intercept /j/	0.753		0.757		0.748	
/a/	0.172	40.13	0.143	27.67	0.074	14.91
/r/	0.011	2.8	0.012	2.47	0.029	5.98
/l/	0.005	NS	0.023	4.65	0.042	8.61
/s/	–0.023	–5.61	–0.022	–4.60	0.004	NS
Intercept /r/	0.764		0.769		0.778	
/j/	–0.011	–2.8	–0.012	–2.47	–0.029	–5.98
/a/	0.160	37.38	0.131	25.3	0.044	8.94
/l/	–0.006	NS	0.010	2.17	0.013	2.63
/s/	–0.035	–6.08	–0.035	–7.7	–0.025	–5.09

The three models were refitted 3 times each with a different intercept: /a/, /j/, /r/.

once again, marginal. In sum, a scale in the following order may be deducted from the statistical exploration: /a–/ > /l–/ > /r–/ > /j–/ > /s–/. A closer look (see β values in table 2) suggests that the differences between the three intermediate steps (/l r j/) were much smaller than the other differences (/a–/ > /l– r– j–/ > /s–/). Notice that the difference between /a/ and all other levels is much larger than that between any of the other pairwise contrasts (see also fig. 9).

Finally, regarding /g/ (n = 1,797), the model in which the /a/ context was the intercept revealed that all other contexts triggered more constricted consonant realizations than this one, the largest differences being between /a/ and /j/ and between /a/ and /s/ (see β values in table 2). The first refitted model (/j/ was the intercept in this case) showed, in addition, that /g/ in the context of /j/ was more constricted than when preceded by /r/ or /l/ (as well as /a/) but, interestingly, not when this consonant was preceded by /s/. The third model further revealed that /g/ tokens preceded by /r/ were significantly more weakened than when preceded by /s/ (as well as /j/) and slightly more constricted than when preceded by /l/. In sum, a scale from more lenited to more constricted emerged from the data: /a–/ > /r–/ > /l–/ > /j– s–/. However, the difference between the /r/ and /l/ contexts seems to be much smaller than that between other comparisons, thus suggesting the following scale: /a–/ > /r– l–/ > /j– s–/.

To summarize our results for Costa Rica: (1) Unlike in Madrid Spanish, a difference was found between word-initial and word-medial position (word-medial tokens being more lenited). (2) Like in Madrid Spanish, there is an effect of the preceding segment. A remarkable fact is that there is a very large difference between the context after

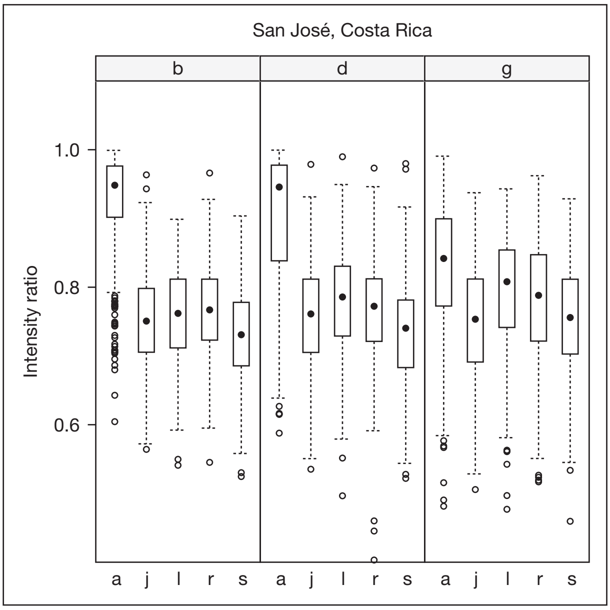

Fig. 9. San José, Costa Rica. Box plots of intensity ratio values as a function of place of articulation (/b d g/) and preceding context (/a j l r s/).

/a/ and all other contexts; this was the case for /b/ and /d/ in particular. We will return to this result in the next subsection. (3) Like in Madrid Spanish, intensity ratios are greater in stressed syllables than in unstressed ones, although, as was mentioned in the 'Methods' section, this difference may be due, at least in part, to the greater energy of stressed vowels, rather than to greater constriction of consonants in stressed syllables. (4) Finally, like in Madrid Spanish, there was less lenition in the task where speakers read words in isolation than in the other two tasks.

Comparing the Two Dialects

Cursory examination of the coefficients (β values) returned by the regression models reported in tables 1 and 2 suggests that the sizes of the differences between /b/ and /d/ tokens preceded by /a/, and /b/ and /d/ tokens preceded by other segments is much larger for Costa Rica than for Spain. Also, the magnitude of the difference between Costa Rican /b/ and /d/ tokens preceded by /a/ and all other tokens of these consonants is much greater than the difference between /g/ tokens preceded by /a/ and all other /g/ tokens in this dialect.

This finding, together with a visual inspection of the box plots of the distributions of ratio values in figures 8 and 9, suggests that the processes that trigger the differences in consonantal constriction as a function of the preceding segment are of a different nature in the two dialects. In particular, the data are consistent with an interpretation according to which constriction of /b d g/ in the data from Madrid are affected by phonetic, gradient processes while constriction of /b/ and /d/ (but not /g/) in Costa Rican Spanish are affected, in addition, by a phonologization of one of these gradient effects.

In order to further explore the difference between Costa Rica and Spain with regard to the realization of /b/ and /d/, we plot the density of the distributions of /b/,

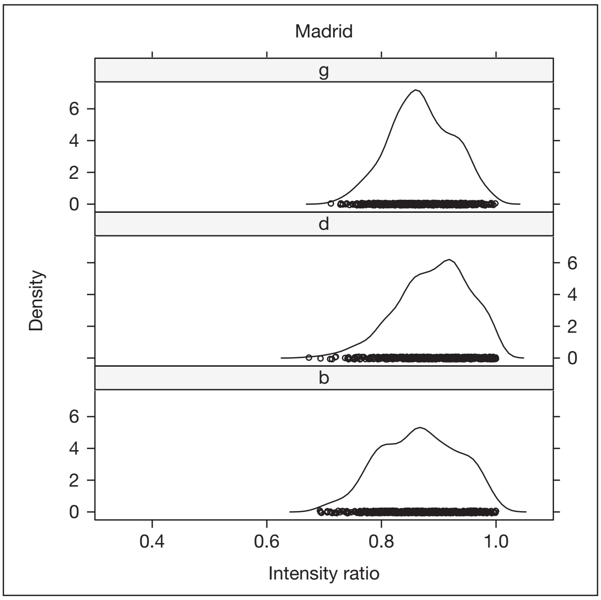

Fig. 10. Density plots of intensity ratios of /b d g/ for Madrid, Spain.

/d/, and /g/, respectively, as a function of dialect. This further allows the reader to see whether the distributions of ratio values for these consonants in the two dialects are uni- or bimodal. The density plots are shown in figures 10 (Madrid, Spain) and 11 (San José, Costa Rica).

The density plots in these two figures show that the distributions of ratio values for the Costa Rican /b/ and /d/ are clearly bimodal while they are unimodal for Spain. Also, it is important to note that the width of the entire distribution is much larger for Costa Rican Spanish than for Madrid Spanish. In addition to the fact that 7 more speakers from Costa Rica than for Madrid are included in these densities, we believe the data suggests that the larger width of the Costa Rican distribution is due to a wider separation in constriction degree between the different contextual realizations of these consonants in this dialect than in the Madrid dialect (also in by-speaker distributions). The box plots shown in figure 9 clearly indicate that the upper mode (i.e. the rightmost mode) in each of two Costa Rican bimodal densities is due to /b/ and /d/ consonants preceded by /a/. Notice that the density of Costa Rican /g/ does not pattern with that of /d/ and /b/ in this dialect. Regarding Spain, the densities for /b/ and /d/ are clearly unimodal. By unimodal we mean that there is no clear evidence of a valley or dip between two peaks or modes in the densities. In our opinion, the little ‘bumps’ in the unimodal distributions for Spain suggest the existence of gradient phonetic effects, some of which result in significant statistical differences (see above). On the other hand, the clearly bimodal densities for Costa Rica suggest the existence of at least one phonologized difference.

Note that there are more outliers in the Costa Rican distributions than in the Madrid ones. The following two points may be taken into consideration: (1) The Costa Rican data comprises many more observations, from several more speakers, than the Madrid data. It is perhaps not surprising that more outliers are found in this distribution of data. (2) The Costa Rican data is spread over a wider area in general. This is

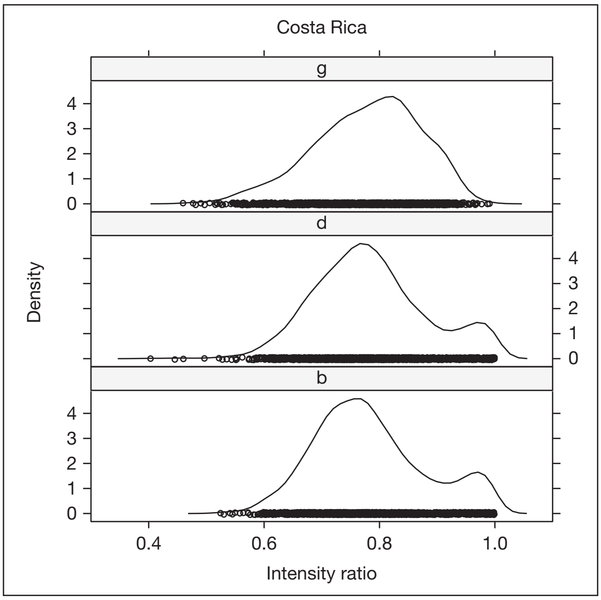

Fig. 11. Density plots of intensity ratios of /b d g/ for San José, Costa Rica.

particularly obvious in the case of /b/ in the context of /a/: there are several outliers of the /a/ distribution that seem to fall within the central region of the distribution typical of /b/ in other contexts. This, in our opinion, supports our interpretation that /b/ realizations in the context of a preceding vowel have been qualitatively split off from the central tendencies for this consonant, leaving some outliers behind.

It is important to highlight that the phonetic factors that seem to affect /b d g/ in our Madrid data are also found in the Costa Rican data. In other words, none of the distributions are fully normal and unimodal because they are all significantly affected by the phonetic factors we have examined, which have nonnegligible effects on the degree of lenition of these consonants. Our view here is that the Costa Rican data are affected by both phonetic and phonological (phonologized) factors. In Costa Rican Spanish, the consonants /b/ and /d/ are produced within different 'windows' [Keating, 1990] after a vowel and in all other contexts.

Discussion

Summary and Interpretation

Our acoustic investigation has revealed a number of factors regarding the allophony of /b d g/ in Costa Rican Spanish and how this variety differs from Peninsular Spanish in this respect.

First of all, in both dialects, we find an effect of stress: tokens at the onset of a stressed syllable are more constricted than after the stress. This confirms results in other acoustic studies of Spanish spirantization [Cole et al., 1999; Ortega-Llebaria, 2004; Eddington, 2011]. As noticed above, however, stress effects in our measurement need to be interpreted with care, since they may have been caused by greater intensity in stressed vowels rather than by greater constriction and less intensity in the target consonants preceding them. On the other hand, Fernandez [1982] did not find a stress-conditioned difference in the distribution of continuant and noncontinuant allophones.

Regarding word boundaries, in Costa Rican Spanish the target consonants were found to be more lenited in word-medial than in word-initial position. For Peninsular Spanish no effect of the presence of a preceding word boundary was found. Eddington [2011] found an effect of word boundaries, restricted to intervocalic tokens, and only for /b/ and /d/. The statistical model to which we submitted our data did not allow us to determine whether the statistical effect of position in words that we found for Costa Rica was limited to only one or two of the consonants. Again, Fernandez [1982] did not find a difference between the word-medial and the word-initial contexts.

As for differences among the three consonants that we have examined, observation of box plots and density plots shows that generally in postconsonantal position /g/ is weaker than /b/ and /d/ in Costa Rican Spanish. This difference, however, is not found in postvocalic position, where the opposite is true (fig. 9). This may be related to our choice of the vowel /a/. As noted in the 'Introduction', Cole et al. [1999] and Ortega-Llebaria [2004] found more constricted realizations of /g/ between low vowels than in other contexts, whereas Simonet et al. [2012] found less constricted realizations of /d/ after lower than after higher vowels. We surmise that this may have to do with the fact that /g/ can shift its point of articulation to coarticulate with vowels.

Asymmetries among the voiced plosives have been noted for other related languages. In Majorcan Catalan, /b/ is significantly more constricted than /d/ and /g/. Hualde et al. [2010, pp. 75–76] appeal to the aerodynamic voicing constraint of Ohala and Riordan [1979] and Ohala [1983, 1997] to explain this fact. Similarly in Rome Italian intervocalic /d/ and /g/ show some tendency to become approximants (although not with the regularity they do in Spanish), but /b/, instead, geminates in this position [Hualde and Nadeu, 2011].

The most important difference between Peninsular Spanish and Costa Rican Spanish emerging from our data is in the way the target consonants are affected by immediately preceding segments.

For Peninsular Spanish, we find a unimodal distribution of realizations with a continuum of constriction degree (as reflected in the intensity curve) depending on the nature of the preceding segment. Among the consonants and glides that were considered in the preceding environment, the ones that induced the most constricted realizations of a target consonant were /s/ and also /l/ in the case of the sequence /ld/. That is, we found the hierarchies of constriction for the target consonants in Madrid Spanish that are shown in table 3.

This is in agreement in part with the traditional account, according to which /d/ is a stop after /l/, and also in part with other recent acoustic studies, that also have found very constricted realizations of the voiced obstruents after /s/ [Martínez-Celdrán and Regueira, 2008; Eddington, 2011]. We did not test for statistical differences between /ld/ and /sd/. For Costa Rica as well, the context after /s/ appears to trigger more constricted target consonants than other contexts. We want to point out that preconsonantal /s/ was occasionally aspirated or auditorily deleted in our Costa Rican data, although this is not a frequent feature of our corpus or of this Spanish dialect. Nevertheless, spectrographic inspection shows that aspirated or deleted /s/ still triggers a constricted realization of a following voiced plosive. An example is given in figure 12. The example is the word *posdatado* 'postdated', realized as [podaˈtaᶞo]. Notice the great difference

Table 3. Statistically significant differences in degree of constriction of /b d g/ by preceding environment, from most to least open

Madrid, Spain	San José, Costa Rica
/b/: /a–/ > /j–/ > /r–, l–/ > /s–/	/b/: /a–/ > /j–, r–, l–/ > /s–/
/d/: /a–/ > /j–/ > /r–/ > /l–, s–/	/d/: /a–/ > /l–/ > /r–/ > /j–/ > /s–/
/g/: /a–/ > /j–, r–, l–/ > /s–/	/g/: /a–/ > /r–, l–/ > /j–, s–/

in degree of constriction between the two instances of /d/ in this example. Although the first /d/ appears to be postvocalic on the surface, it is preceded by an 'underlying' /s/.

This is consistent with results reported by Amastae [1989] for Honduras Spanish, a dialect with more extensive weakening of /s/. Amastae [1989] finds the same tendency for preceding /s/ to inhibit spirantization of /b d g/ regardless of its realization as an alveolar fricative as aspirated or as (auditorily) deleted. The constricted realization of /b d g/ after deleted /s/ creates the conditions for a new phonological opposition e.g. *la b̲ata* [aˈβa] 'the robe' versus *las b̲atas* /asba/ [aˈba], a development that has been claimed for Canary Island Spanish [see e.g. Dorta and Herrera, 1993].

In a recent combined acoustic and electropalatographic study of Peninsular Spanish, Hualde et al. [2011a] found fewer instances of complete occlusion of /d/ after /s/ than after /l/ or /n/. They attribute the low intensity of /d/ in /sd/ reflected in the acoustic signal, that they also find, to the narrow passage created by the fricative. That is, voiced obstruents after /s/ may show a small intensity ratio, due to a high degree of constriction, even if complete obstruction is not as frequent as in /ld/ (or after a nasal, a context not tested in the present study).

Hualde et al. [2011a] also note that in homorganic sequences, that is, after a nasal and in /ld/, the acoustic signal may not always clearly reflect the presence of a voiced oral stop. In the case of sequences involving nasals, such as /nd/, the apicoalveolar contact may be coextensive with the presence of nasal flow, so that the presence of /d/ after /n/ is cued by an absence of nasalization on the following vowel. A similar reasoning would apply to /ld/. In figure 13 we offer two tokens of *el danés* 'the Dane/Danish' produced by the same Costa Rican speaker. Whereas in figure 13a /d/ is clearly segmentable, in figure 13b the only evidence for its presence is the release bar before the vowel. This may result in higher than expected energy values.

Regardless of the particular intensity-ratio scales that were found, there is an important respect in which our Costa Rican data differ from our Madrid data. Our intensity measurements indicate a large difference between postvocalic and all other tokens for the Costa Rican consonants /b/ and /d/ than we find for Madrid (and for Costa Rican /g/). This can be appreciated in the interaction plots in figure 14, which display intensity ratio means as a function of consonant and preceding segment for the two dialects.

This indicates that in Costa Rica /b/ and /d/ have quite different targets after vowels and in all other contexts, including after glides. This confirms earlier observations, although not for the velar. The usual postconsonantal (including postglide) target in Costa Rican Spanish for /b/ and /d/ would be a noncontinuant or stop realization, subject to online reduction, whereas the postvocalic target is an approximant, as in Peninsular Spanish. We acknowledge the fact that our intensity-based metric does not

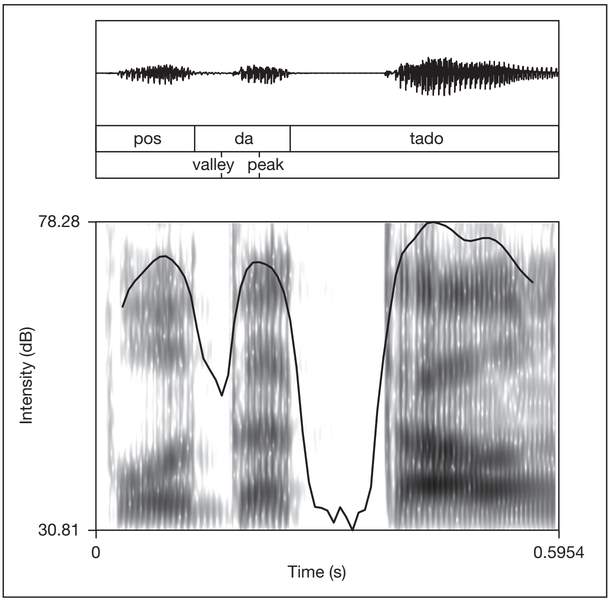

Fig. 12. Sound wave, spectrogram and intensity contour of the word *posdatado* 'post-scripted' uttered by a male speaker from San José, Costa Rica.

allow us to claim that /b/ and /d/ allophones used in postvocalic positions in Costa Rican Spanish are indeed stops. We reach this conclusion based on spectrographic observations of our data (see, for instance, the intensity curves in fig. 1–6). The results of our intensity-based study would be in agreement with such an understanding, even though they would not prove that this is the case. Nevertheless, what we wish to highlight is that the degree of separation between postvocalic and postconsonantal (and postglide) realizations of /b/ and /d/ in Costa Rican Spanish is much larger (in intensity, and presumably also in other phonetic features) than in Madrid Spanish. We claim that the cognitive relation between /b/ and /d/ allophones in Costa Rican Spanish is of a different nature than that of those in Madrid Spanish.

A possible parallel, by way of illustration, may be established with the patterns of vowel length differentiation in English stressed monosyllables [Bybee, 2001, pp. 43, 44]. In English, vowels are longer when they precede voiced obstruents (*bed*, *cab*) than when they precede voiceless ones (*bet, cap*), as they are in many other languages. Importantly, the magnitude of the length difference in English is much larger than in other languages [Zimmerman and Sapon, 1958; Chen, 1970]. This finding suggests that the (perhaps) universal phonetic pattern that triggers a length difference between vowels in these phonetic contexts has been reanalyzed in English as a phonological difference, i.e. there has been an allophonic split or a phonologization of a phonetic pattern. Hyman [1975, p. 172] wrote: 'It thus appears that English has extended this vowel-length difference beyond the normal range predictable from the phonetics'.

Historical Explanation

In this section we offer some speculation on how this situation arose historically. Canfield [1981] considers that the distribution that we find in Costa Rica and other regions, with a preference for noncontinuant allophones in postconsonantal position,

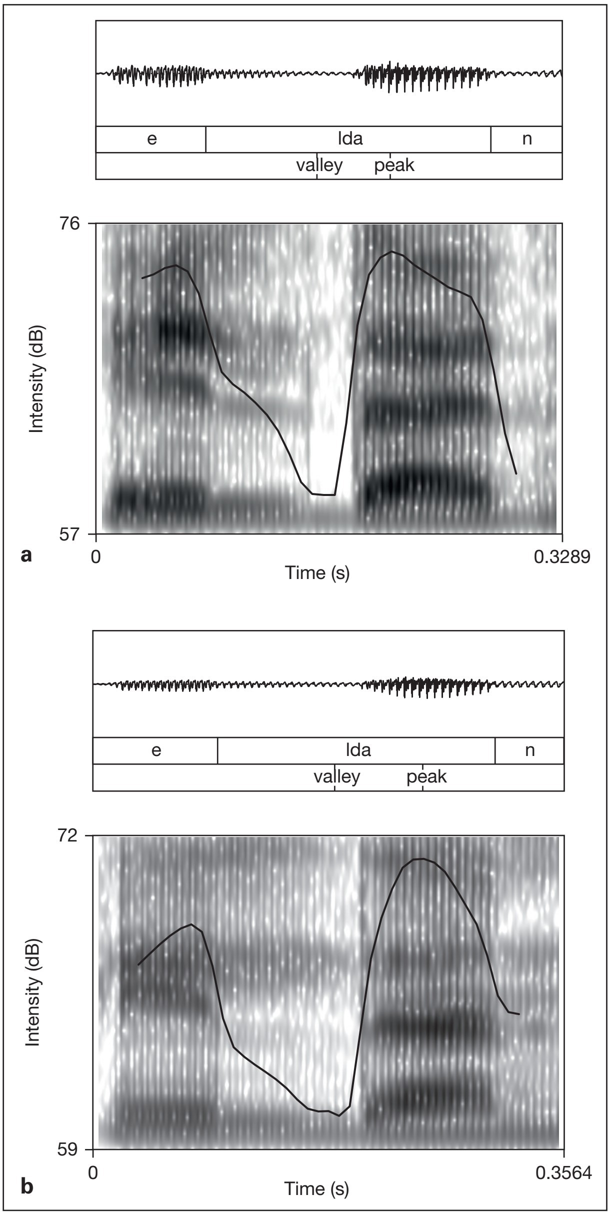

Fig. 13. Sound wave, spectrogram and intensity contour of two different tokens (**a**, **b**) of the word *el danés* 'the Dane/Danish' produced by a female speaker from San José, Costa Rica.

is an archaism or conservative trait; that is, it represents an earlier stage than the more extensive weakening of /b d g/ that we find elsewhere. Fernandez [1982], on the other hand, tentatively suggests that this is instead an innovation with respect to the more general system of allophony. Fernandez [1982, p. 135], in fact, hypothesizes that we are dealing with a relatively recent sound change in progress 'tending towards a system in which the occlusives are heard in group-initial position and after consonants and glides,

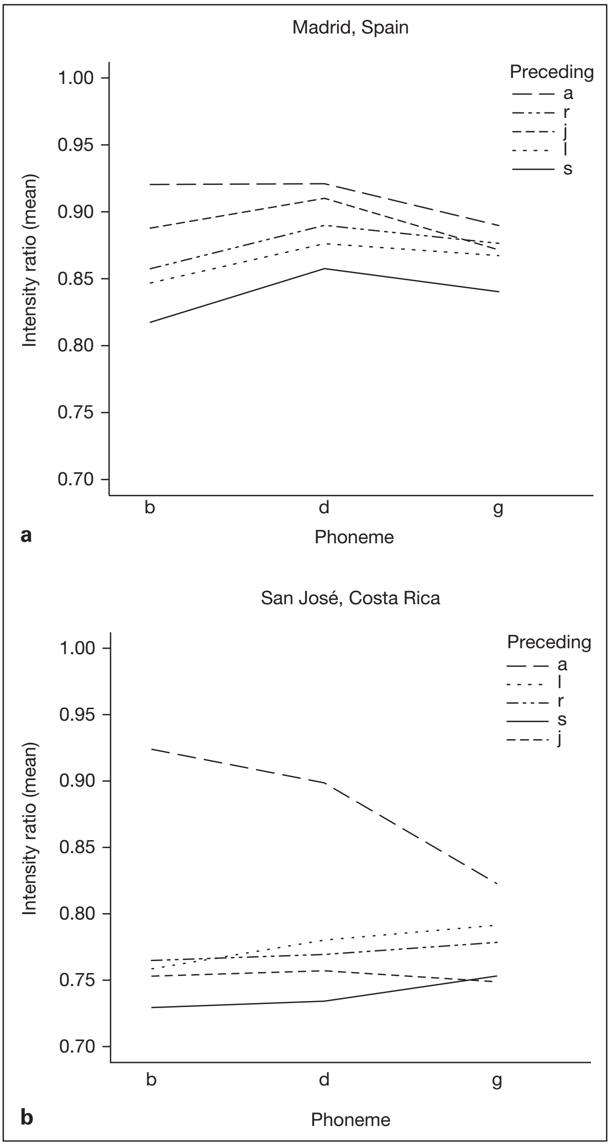

Fig. 14. Interaction plots displaying means of intensity ratios as a function of consonant and preceding segment for Madrid, Spain (**a**), and San José, Costa Rica (**b**).

while fricatives are heard elsewhere'. Fernandez [1982] bases his hypothesis primarily on the fact that he found stops in contexts beyond those mentioned for the occurrence of these allophones in Chavarría-Aguilar's [1951] brief description of Costa Rican Spanish phonology and on inferences from statements in other works on other Latin American varieties. In his view, the trend towards stop allophones after all consonants and glides would have advanced in the few decades between Chavarría-Aguilar's description and his own work. The fact that we found weaker allophones in less formal styles does not support the hypothesis of a change in progress towards greater constriction.

Comparison with another, similar, consonant-weakening process in Spanish and other Romance languages, suggests, however, that weakening after a consonant or glide is likely to be an extension of a process that starts in postvocalic position. Consider the parallels offered by the lenition of voiceless obstruents in Western Romance and the earlier lenition of /b/ in Late Latin.

We start with the example of Western Romance voicing. Whereas in intervocalic position Latin P T C are systematically voiced in Spanish (and other Western Romance languages), as shown in (2a), such voicing did not take place after a consonant or glide (2b):

(2)

a. Latin intervocalic P T C		
SAPĒRE	*saber*	'to know'
VĪTA	*vida*	'life'
AMĪCA	*amiga*	'friend, fem.'
b. Latin P T C after consonant or glide		
CORPU(S)	*cuerpo*	'body'
PORTA	*puerta*	'door'
PORCU	*puerco*	'pig'
PAUCU	*poco*	'little'
SAPIAT > **saipa*	*sepa*	's/he know, subjunctive'

An earlier process, most likely accomplished by the first century, was the weakening of intervocalic B, causing its merger with V in all Romance languages [Herman, 2000, p. 45]. In most Romance languages, postconsonantal B is not affected, but in Portuguese it also becomes /v/ [Williams, 1962, p. 91]:

(3)

	Italian	French	Catalan	Portuguese	
HABĒRE	*avere*	*avoir*	*haver*	*haver*	'to have'
DEBĒRE	*dovere*	*devoir*	*dever*	*dever*	'to owe'
CARBŌNE	*carbone*	*charbon*	*carbó*	*carvão*	'coal'
HERBA	*erba*	*herbe*	*herba*	*erva*	'grass'
ARBORE	*albero*	*arbre*	*arbre*	*arvore*	'tree'
ALBA	*alba*	*aube*	*alba, auba*	*alva*	'dawn'

Given the fact that the weakening of intervocalic B is pan-Romance and, after a liquid, instead, the phenomenon is geographically limited to part of Ibero-Romance, it must be the case that Portuguese shows the generalization to some postconsonantal contexts of a weakening process of /b/ that at a first stage affected only intervocalic tokens.

Drawing parallels from these other sound changes, where the evidence is more straightforward, it seems reasonable to conclude that the more restricted spirantization of /b d g/ that we see in Costa Rican Spanish when compared to other dialects must represent a more conservative stage.

An important caveat is, however, in order. One cannot exclude the possibility that at the time Spanish was implanted in Costa Rica the lenition of /b d g/ had already affected (some) postconsonantal contexts, so that there has been a partial regression in lenition, as Fernandez [1982] suggests.

It is clear that accomplished sound changes where there has been phonemic recategorization may hide earlier variation in contexts where the sound change was not phonologized. For instance, there is substantial evidence that the voicing of intervocalic stops in Western Romance operated across word boundaries at an earlier stage even if it was eventually phonologized only inside words [Weinrich, 1958; Cravens, 2002; Hualde et al., 2011b]. Although in Costa Rican Spanish there has not been phonemic recategorization, it is possible that the clear allophonic split that we find between postvocalic and all other contexts for /b/ and /d/ represents a simplification of earlier variation. Perhaps the most parsimonious hypothesis is the following: The lenition of /b d g/ in Spanish likely started in the postvocalic context, since this is what comparison with other similar processes suggests. In the 16th century, when the Spanish language was taken to Costa Rica, lenition of /b d g/ was systematic in the postvocalic context, but variable after consonants and glides. Since then, the tendency has been to favor strong, nonlenited pronunciations of /b/ and /d/ in those contexts that earlier showed more variation, with regression of lenition in these contexts.

The evolution of spirantization in Judeo-Spanish may offer another useful parallel, since the formation of Judeo-Spanish, after the expulsion of the Spanish Jewry in 1492 and their settlement in lands of the Ottoman Empire, roughly coincides with the spread of the Spanish language in Latin America. A crucial difference is that, after the Spanish Jews settled in the Ottoman Empire, they lost all contact with other varieties of Spanish, so that Judeo-Spanish shows an independent evolution from that time on, whereas Latin American Spanish continued in contact with Peninsular Spanish.

The development of the voiced labial stop from Old Spanish in Judeo-Spanish is different from that of the other two consonants, as Old Spanish had a contrast between a fricative /v/ (variably bilabial /β/ or labiodental /v/ depending on the area) and a plosive /b/. Although there is some evidence that the contrast became unstable in some regions from a fairly early period, the works of Nebrija [1492/1946, 1517/1977] and Valdés [1535/1928] show a stable phonemic contrast. The phonological contrast was still present in some geographical areas when the orthography reformer Korreas [1630/1971] wrote his work, although by then it had already been lost in many regions. In fact, the contrasts survived up to the 20th century in a few marginal areas [Ariza, 1989]. What caused the neutralization of the two labial consonants was the spirantization of /b/.

In Judeo-Spanish, the Old Spanish contrast has been preserved in word-initial position [e.g. *(la) boka* '(the) mouth', *(la) vaka* '(the) cow', see Perahya and Perahya 1998]. Word-medially after a vowel there has been neutralization in favor of /v/, e.g. O.Sp. *saber* > *saver* 'to know', O.Sp. *lobo* > *lovo* 'wolf', O.Sp. *cobdo* > *kovdo* 'elbow', etc. This is completely systematic, so that the only instances of intervocalic /b/ in Judeo-Spanish are found in borrowings from other languages and after prefixes, e.g. *a-bashar* 'to lower'. After a liquid or fricative, we find in general the same development as postvocalically, e.g. *yerva* 'grass' (Lat. HERBA, Sp. *hierba*), *arvolé* 'tree' (Lat. ARBORE, Sp. *árbol*), *alvorada* 'dawn' (Lat. ALBA, Sp. *alba*), *karvon* 'coal' (Lat. CARBŌNE, Sp. *carbón*), but there are a few exceptions, e.g. *albondigá* 'meat ball' (Sp. *albóndiga*), *arresvalar* 'to slip'(Sp. *resbalar,* but also attested as *resvalar* in O.Sp.). (We have found no examples after a glide.) After a nasal, on the other hand, neutralization has been in favor of /b/, e.g. *embidya* 'envy' (Sp. *envidia*), *embiar* 'to send' (Sp. *enviar*), but again with a few exceptions, e.g. *invyerno* 'winter' (Sp. *invierno*). These developments can be interpreted as showing that, at the time of the separation between Judeo-Spanish and other Spanish varieties, lenition of /b/ was general in intervocalic position, causing its systematic merger with historical /v/, whereas there was variation in postconsonantal positions. (The maintenance of the old phonemic contrast in word-initial position, unlike in modern Peninsular and Latin America Spanish can be attributed to language contact and would show regression of lenition in the word-initial postvocalic context [Hualde, in press].)

Regarding the voiced dental, in Istanbul Judeo-Spanish continuant realizations are systematically found only in word-internal intervocalic position, whereas stops are found in all postconsonantal positions, e.g. *verdađero* 'true' [Perahya and Perahya, 1998; Hualde and Şaul, 2011; Hualde, in press]. Stops are also preferred word-initially, even if intervocalic, e.g., *kađa dia* 'each day'. Even prefix boundaries prevent spirantization, *a*- [d]*elgasa*r 'to become thin'. Furthermore, [d] is found in intervocalic morpheme-internal position in borrowings. For instance, native *kađa* 'each' contrasts with the Turkish borrowing *adá* 'island'. Arguably, then, the contrast between /d/ and /ð/ has been phonemicized. One view could be that the distinction between postvocalic and postconsonantal contexts in both Istanbul Judeo-Spanish and Costa Rican Spanish reflects a common stage of development, which was found in 15th century Spanish. Notice, nevertheless, that an important difference between these two varieties concerns the effects of morpheme boundaries, which block spirantization in Istanbul Judeo-Spanish, but have a less pronounced effect in Costa Rican Spanish (although we found a significant distinction between word-initial and word-medial contexts in the degree of constriction). The most plausible explanation is that the blocking of spirantization due to intervening morphological boundaries in Istanbul Judeo-Spanish is an analogical restoration of word-initial stops [Hualde, in press]. If this is correct, it could also be that earlier variation in postconsonantal contexts has been solved in favor of the stops. For the velar /g/, realizations without full occlusion are generally favored in Istanbul Judeo-Spanish in all contexts, even after a pause.

The most parsimonious hypothesis leads us to the conclusion that there was an earlier common stage to all modern Spanish varieties, including Judeo-Spanish, where approximant realizations of /b d g/ were general in intervocalic position, but where realizations after liquids, sibilants and glides were not as open and/or presented more variability. In Costa Rica (and other varieties with the same pattern), stop realizations came to be preferred in all nonpostvocalic positions, with a greater allophonic differentiation, as reflected in our density plots. This view is to a great extent in agreement with Fernandez's [1982], although we do not think this is necessarily a very recent phenomenon.

This is, however, not the only possibility. It cannot be excluded that the spirantization process was less consistent in 15th century Spanish than it is nowadays, also in intervocalic position, since fully occluded realizations of these consonants, even when intervocalic, are still found both in Portuguese [Mateus and d'Andrade, 2000] and some Catalan varieties [Recasens, 1991; Hualde et al., 2010]. The considerable agreement in the allophony of /b d g/ that we find across much of the Spanish-speaking world [Canfield, 1981] could be due to later shared developments, as we find in several other aspects of pronunciation, such as the generalization of the devoicing of the voiced fricatives and the velarization of the old prepalatals, that postdate the separation of Judeo-Spanish.

Conclusion

To sum up and conclude, a well-known phenomenon of Spanish phonology is the allophonic spirantization of the voiced obstruents /b d g/. Something that is not so well known is that there is some important geographical variation in this allophonic process. In particular, in parts of Central America, including Costa Rica, and in the highlands of Colombia, stop allophones are frequent in all postconsonantal contexts and after glides. Although this variation is, for the most part, below the awareness of native speakers (i.e., it is not consciously imitated and does not form part of any stereotypes), it is salient to the phonetically trained ear and has been noted in dialectological work. To our knowledge, the only previous study of Costa Rican Spanish spirantization that has gone beyond casual observation is Fernandez [1982], where the allophones of /b d g/ in a corpus of Costa Rican Spanish are classified in a binary fashion based on the author's auditory perception and visual inspection of spectrograms [for Honduras see Amastae, 1989]. In this article we have attempted to go beyond previous work by employing a more objective, quantifiable measurement of the degree of constriction for these consonants and establishing a comparison with Peninsular Spanish. We believe our analysis has provided us with a more complete and detailed understanding of the facts. We have also developed a possible historical account that would explain the dialectal differences that we find.

Acknowledgments

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Appendix

Materials

/a_/ context: Stressed, word-initial: *la/una bata, la dalia, la gata*. Stressed, word-medial: *caballo, badajo, agave.* Unstressed, word-initial: *la ballena, la danesa, la garrafa*. Unstressed, word-medial: *caballero, adalid, lagartija*.

/j_/ context: Stressed, word-initial: *muy bajo, muy dado, muy gárrula*. Stressed, word-medial: *seibano, deidades, arraigado*. Unstressed, word-initial: *muy barato, muy dañina, muy galana*. Unstressed, word-medial: *ceiba, Almeida, meiga*.

/r_/ context: Stressed, word-initial: *ser bajo, hacer daño, colocar gárgolas*. Stressed, word-medial: *corbata, verdad, alpargata*. Unstressed, word-initial: *ser barbero, hablar danés, ser gallego*. Unstressed, word-medial: *barbacoa, bordadora, bergamota*.

/l_/ context: Stressed, word-initial: *el báculo, el dátil, el gato*. Stressed, word-medial: *silbato, aldaba, cabalgata*. Unstressed, word-initial: *el bastón, el danés, el ganado*. Unstressed, word-medial: *albacora, baldaquino, algarroba*.

/s_/ context: Stressed, word-initial: *los bates, los dados, los gallos*. Stressed, word-medial: *desbaste, posdata, desgaste*. Unstressed, word-initial: *las bayonetas, los damanes, las galeras*. Unstressed, word-medial: *resbalón, posdatado, rasgadura*.

(Target consonants are underlined.)

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