# Consonant lenition and phonological recategorization

JOSÉ IGNACIO HUALDE, MIQUEL SIMONET and MARIANNA NADEU

*University of Illinois at Urbana-Champaign*
*University of Arizona*
*University of Illinois at Urbana-Champaign*

*Abstract*

*We examine the weakening of intervocalic voiceless stops in Spanish in order to gain insight on historical processes of intervocalic lenition. In our corpus, about a third of all tokens of intervocalic /ptk/ are fully or partially voiced in spontaneous speech. However, even when fully voiced, /ptk/ tend to show greater constriction than /bdg/, with the velars being less different than labials and coronals. Word-initial and word-internal intervocalic segments are equally affected. Based on our findings from acoustic measurements of correlates of lenition, we propose that common reductive sound changes, such as intervocalic consonant lenition, start as across-the-board conventionalized phonetic processes equally affecting all targets in the appropriate phonetic context. The common restriction of the sound change to word-internal contexts may be a consequence of phonological recategorization at a later stage in the sound change.*

## 1. Introduction

Linguistics became a scientific discipline through the study of sound change and much progress has been made in our understanding of the phonetic sources of many sound changes. Nevertheless, we still cannot say that we understand the phenomenon of sound change completely.

For at least some sound changes, their phonetic origin is now reasonably clear. Reductive changes, including assimilations and lenitions, on which we want to focus here, are widely believed to be the most frequent types of changes and are among the best understood. In the theory of Articulatory Phonology (Browman and Goldstein 1991), in particular, it is postulated that assimilation and lenition, among other sound changes, are the result of gestural reduction or undershooting of targets and overlap in casual speech. Whereas this model offers a convincing explanation of the origin of the phenomena, the conventionalization of specific reductive processes in some languages and possible subsequent phonological recategorization fall outside of the purview of this theoretical model.

JLP 2 (2011), 301–329
DOI 10.1515/LABPHON.2011.011
1836-6346/11/02–301

In this paper we will focus on a common reductive process, the lenition of intervocalic stops. Even in the case of such frequent historical changes, there are a number of unresolved questions.

If we take, for instance, the sound change p > b between vowels, the incomplete abduction of the vocal cords in casual speech explains intended /apa/ being realized as [aba]; but for a sound change p > b to take place recategorization must ensue: /apa/ [aba] > /aba/ [aba] (see Hyman 1976). We say that the sound change p > b has taken place in Lat. LUPU(M) > Sp. *lobo* 'wolf', because the medial consonant of this word is now identified with the initial consonant of other words like *boca* 'mouth', and not with that of *puerta* 'door', whereas in Latin LUPU(M) had the same medial consonant phoneme as appears in initial position in PORTA 'door'. The question is then how this recategorization took place.

Ohala (1974, 1990, 2003, among other publications) has argued that sound change is due to listeners interpreting unintended consequences of articulatory reduction and overlap as intended. This is most likely correct and has to be part of the answer. Notice, however, that, since in casual speech unintended reductions can be very varied, they could give rise to many possible reinterpretations of the same sequence in the same language. One could in principle find that the same phonemic sequence is reinterpreted in completely different ways in different words. For instance, in the same language we could find the hypothetical evolutions of the sequence /apa/ illustrated in (1).

(1) Hypothetical diachronic reinterpretations of /apa/ in different words
mapa > maba, napa > nafa, lapa > laa, rapa > rawa, sapa > sapa

As the Neogrammarians taught us, this is not what we typically find when we look at language evolution. Rather, we find that sound change is regular. Consider, to give a specific, well-studied example, the evolution of Latin stops between vowels or between vowel and liquids in the different Romance languages, as illustrated with a few examples in Table 1.[1]

In the Western Romance languages (i.e. those found north and west of the isogloss known as the La Spezia-Rimini line, which runs across northern Italy [Wartburg 1936, 1950]), Latin intervocalic /ptk/ were systematically voiced. In central-southern European Portuguese and in Brazilian Portuguese, intervocalic /bdg/,

Table 1. *Evolution of intervocalic Latin stops in four Romance languages*

| Latin | Portuguese | Spanish | French | Italian | |
|---|---|---|---|---|---|
| SAPĒRE | *saber* | *saber* | *savoir* | *sapere* | 'to know' |
| CAPRA | *cabra* | *cabra* | *chèvre* | *capra* | 'goat' |
| ROTA | *roda* | *rueda* | *roue* | *ruota* | 'wheel' |
| VĪTA | *vida* | *vida* | *vie* | *vita* | 'life' |
| AMĪCA | *amiga* | *amiga* | *amie* | *amica* | 'friend, fem.' |
| SECŪRU | *seguro* | *seguro* | *sûr* | *sicuro* | 'safe, masc.' |

from the voicing of Latin /ptk/, are usually realized as voiced stops. In Spanish, these sounds underwent further reduction and phonemic /bdg/ are systematically realized as approximants between vowels. Finally, in French the labial became a labiodental fricative and the coronal and velar were further weakened up to their deletion. In Western Romance we thus find systematic voicing of intervocalic stops, which was followed by further lenition in some of the languages. The reason for this regularity, given the many possible reductions in casual speech and possible mistakes in categorization on the part of listeners, is something that we still need to understand. Here we offer the suggestion that the reason we don't typically find patterns like that illustrated in (1) (which would make the application of the comparative method impossible) is that phonological recategorization usually operates on prior conventionalized phonetic processes of reduction. In a given speech community intervocalic /p/ may tend to be confused with /b/ by listeners, and not with /f/ or /w/, because the reduction process that has become established in the community is "subphonemic" voicing of this segment.[2]

To continue with our example, another important aspect of the Western Romance voicing of intervocalic stops that needs to be taken into account, which its putative phonetic origin in itself does not explain, is the fact that it was restricted to the word-internal context (see Table 2).

The examination of sound change in progress may show whether lenition tends to occur first and more systematically in word-internal contexts, which may explain its phonologization exclusively in those contexts, or, rather, if it occurs across morphological and syntactic boundaries, subject only to phonetic conditioning. If the latter, the restriction of voicing to the word-internal context may be a later analogical development, as several authors have argued (Weinrich 1958; Hall 1964; Cravens 2002). From the perspective of exemplar models of lexical representation (Pierrehumbert 2002; Bybee 2000, 2002, among others), it seems that word-initial consonants should be expected to undergo less lenition than word-medial ones, since word-initial targets would be in the context of the lenition only sometimes (when preceded by a word ending in a vowel) and tokens of the same word are claimed to have an influence on each other.

To try to shed some light on these issues, in this paper we will consider the incipient voicing of intervocalic stops that we find in some contemporary Spanish varieties. This is based on the hypothesis that the prelude to sound change can be found in synchronic variation and that the analysis of variation in speech may illuminate aspects of older, accomplished sound changes.

Table 2. *Word-internal vs. word-initial intervocalic voiceless stops from Latin to Spanish*

| Latin | Spanish | | Latin | Spanish | |
|---|---|---|---|---|---|
| SAPĒRE | *saber* | 'to know' | ILLA PORTA | *la puerta* | 'the door' |
| VĪTA | *vida* | 'life' | ILLA TURRE | *la torre* | 'the tower' |
| AMĪCA | *amiga* | 'friend, fem.' | ILLA CASA | *la casa* | 'the house' |

To summarize, we have two main research questions in mind, related to the nature of sound change, that arise when we consider a sound change such as the Western Romance voicing of intervocalic stops: (1) How does phonological re-categorization take place? and (2) Is lenition restricted to word-internal contexts at the initial stages of the process? Although it is not our main focus, we will also indirectly consider the issue of lexical diffusion versus lexical abruptness.

Whereas for a chronologically distant process such as the "first round" of voicing in Western Romance we can only speculate on these issues, our hope is that the analysis of what appears to be an incipient "second round" of voicing in Spanish (Oftedal 1985) may provide direct evidence bearing on these questions.

In contemporary Spanish, both voiced and voiceless stops undergo lenition. The lenition of voiced stops is more advanced. Systematically, the phonemes /bdg/ are realized as the approximants [βðɣ] in postvocalic and some postconsonantal contexts. Before turning our attention to the incipient voicing of /ptk/, we will consider the spirantization of /bdg/, which offers a relevant point of comparison for a similar lenition process at a more advanced stage.

## 2. Spirantization of /bdg/ in present-day Spanish

In Spanish the realization of /bdg/ as approximant segments in the intervocalic position ('spirantization') is a completely systematic allophonic phenomenon of the language. Spirantization is found both word-internally and across word boundaries, as illustrated with examples in Table 3.[3]

Whereas fricative or approximant realizations of /bdg/ may be occasionally found in casual speech in many languages, including English (Brown 1977; Browman and Goldstein 1991; Shockey 2003) and French (Duez 1995), in Spanish it is a fully conventionalized process systematically found in all speech styles, including careful reading style. Stop realizations of /bdg/ in intervocalic position would be emphatic or anomalous in Spanish. The actual degree of constriction of these segments, as indirectly revealed by spectrographic analysis, is, nevertheless, very variable and appears to be conditioned by factors such as the position of the lexical stress and the quality of the surrounding vowels (Soler and Romero 1999; Cole et al. 1999; Ortega-Llebaria 2004; Carrasco 2008, etc.).

From this discussion, we thus see that this lenition process has no lexical exceptions and applies both inside words and across word boundaries, unlike Western Romance voicing. In an acoustic study of degree of constriction as revealed by

Table 3. *Spirantization of intervocalic /bdg/ across word boundaries in present-day Spanish*

| | | |
|---|---|---|
| *boca* [boka] | *esa boca* [esaβoka] | 'mouth'/ 'that mouth' |
| *día* [dia] | *otro día* [otɾoðia] | 'day'/ 'another day' |
| *ganas* [ganas] | *tiene ganas* [tjeneɣanas] | 'desire'/ 'has desire' |

intensity differences, Carrasco (2008) finds a small position-in-word effect on degree of constriction (word-medial more lenited than word-initial) for Costa Rican Spanish and no statistically significant effect for Madrid Spanish. Spanish spirantization would thus seem to operate exactly as the Neogrammarians envisioned: In intervocalic position (as well as in some postconsonantal contexts) all instances of /bdg/ are reduced to approximants, regardless of lexical identity or of the presence of morphological or syntactic boundaries.

As mentioned, however, spectrographic analysis shows that actual degree of constriction in different tokens of /bdg/ in lenition contexts varies substantially from very close to very open, vowel-like realizations. The most extreme reduction results in the deletion of the segment, as systematically happened in Old French to the descendants of Latin intervocalic coronal and velar stops (cf. examples in Table 1 above). It should be noted that, whereas the realization of /bdg/ as [βðɣ] is a purely allophonic process in present-day Spanish, its most extreme degree, deletion, involves recategorization. Interestingly, this recategorization is word specific, not across-the-board, and essentially affects the phoneme /d/ in some specific cases. In Peninsular Spanish, participles in /-ado/ have lexical alternants in /-ao/, recognizably perceived and categorized as such, as intended pronunciations (with sociolinguistic significance): *cantado* ~ *cantao* 'sung'. The alternation affects some frequent words with the same ending, such as *lado* ~ *lao* 'side', but not all of them. For instance, *enfado* 'anger' is not known to have a variant ***enfao*, the noun *vado* 'ford' cannot be ***vao* and whereas, as an adjective, we may have *delgado* ~ *delgao* 'thin', the surname *Delgado* does not admit an alternative pronunciation ***Delgao*. Conjugated verbal forms in /-ado/ such as *evado* 'I evade', *invado* 'I invade' do not allow deletion either ***evao*, ***invao*.[4] The intended deletion of /d/ is also found, outside of the /-ado/ context, in some common words like *todo* ~ *to* 'all', *nada* ~ *na* 'nothing', and, across word boundaries, in fixed expressions such as *¿qué (d)ices tú?* 'what do you say?' and phrasal compounds like *traje (d)e novia* 'bride's gown'. That is, although spirantization itself does not have lexical exceptions and affects both word-internal and word-initial consonants, deletion shows clear lexical frequency effects. This suggests that we need to recognize two stages in this weakening process: the conventionalization of the phonetic reduction and the rephonologization of its most extreme results. We see that, as a conventionalized process, that is, as a sub-phonemic phonological rule, Spanish spirantization applies with Neogrammarian regularity. The older voiced stops, still produced as such in Brazilian Portuguese, for instance, have become approximants in intervocalic and other positions in a completely regular fashion. Rephonologization (as zero), on the other hand, operates on a word-by-word or morpheme-by-morpheme basis.

We are thus proposing a model of sound change with two distinct stages. First, a specific reduction process may become conventionalized in a given speech community. In the case of Spanish, the spirantization of /bdg/ has become conventionalized. The degree of spirantization of a specific token will depend on a number on purely phonetic factors, without regard to lexical identity. In this situation, phonological recategorization of specific lexical items takes place essentially as Ohala (1974, and elsewhere) envisions. A listener may interpret, say, *lado* /lado/ as /lao/. At this point this particular lexical item will have acquired two distinct "underlying representations" or, in Articulatory Phonology terms, two gestural scores. There is a gestural score /lado/, whose intervocalic apical gesture can be reduced to different degrees depending on contextual factors, and another gestural score, /lao/, lacking an intervocalic apical gesture. Speakers may choose one or the other on different occasions. If the speaker chooses the form /lado/, the intervocalic apical gesture may be implemented as an approximant with a range of degrees of constriction. If, on the other hand, s/he chooses the form /lao/, there is no apical gesture. Notice that in this view, which we adopt, sound change is phonologically abrupt, even when it appears to be phonetically gradual.

Recategorization may take place item-by-item, as a result of listener's errors in categorization, as Ohala proposes (not necessarily errors in perception). The reason that listeners' reinterpretation will tend to be in the same direction for all words with a given phonological context, producing regularity as the change spreads to more and more lexical items, is that the reduction process that causes misperceptions has previously been conventionalized in the speech community. A crucial claim that this model makes is that before recategorization there are no lexical identity effects. The degree of weakening of intervocalic /d/ in Spanish is not lexically specified. The only thing that is lexically specified is which words and phrases have an optional /d/. If the speaker chooses the form /lado/ for *lado* its /d/ will not differ in degree of constriction from that of *evado* /ebado/ if uttered in exactly the same phrasal, prosodic and discursive context. Of course, this is an empirically testable claim. We leave articulatory testing of this claim for future work.

To be as explicit as possible, at the risk of being repetitive, our claim is that, say, the final /abe/ gesture sequence of high-frequency *sabe* 's/he knows' and low-frequency *arquitrabe* 'architrave' is underlyingly identical and will be articulated in the same manner if the words are uttered in exactly the same prosodic and discursive context. Now, in actual discourse, *sabe* will tend to receive lower prominence than *arquitrabe*, and this will result in a greater chance for *sabe* /sabe/ to acquire an alternative categorically different underlying representation /sae/ for some speakers. With time, /sae/ may or may not completely replace /sabe/ before *arquitrabe* /arkitrabe/ has been recategorized as /arkitrae/. This is different from a view that posits word-specific degrees of reduction for every word in the lexicon.

We are, thus, assuming a quasi-phonemic model of articulatory planning, where the mental gestural scores of all words in the language result from the combination of a limited number of articulatory gestures (Browman and Goldstein 1986, 1989 1991; Goldstein and Fowler 2003), as opposed to an exemplar model of articulation where each word in the lexicon may be specified for its own range of realizations (Bybee 2002; Pierrehumbert 2002). Low-level subphonemic frequency effects, such as the durational shortening of frequent words (Jurafsky et al. 2001;

Gahl 2008, see also Bybee 2002: 268, Bybee 2003: 616) may be an online effect of factors such as the presence of intonational pitch-accents and prosodic boundaries. If in a corpus study we find that, for instance, *time* tends to be shorter than *thyme* (Gahl 2008) this may be a consequence of its being less likely to receive a prominent pitch accent in discourse. The words *time* and *thyme* may, nevertheless, have identical gestural scores and may be realized identically in the same context. Sound change, in our view, involves a discontinuity, the emergence of qualitatively different articulatory phonological representations, as in Ohala's model.[5]

On the face of it, these observations and claims appear to be in direct contrast with other views that have been maintained in the literature on sound change. For instance, Lass (1993: 179) makes the following statement: "The operation of change along the variational and lexical dimensions shows that the earlier we catch a change, the more 'irregular' its reflexes are. Institutionalization of change, like anything else, takes time." In our view, allophonic spirantization, which precedes deletion, is completely regular.[6] It is only the subsequent step, recategorization of words as having a different phonemic composition (or a different underlying gestural score), that shows irregularity. For Lass' statement to be consistent with our facts we must take it to refer to the recategorization stage (the deletion of the consonant in this case).

We may wonder, however, if perhaps we are catching Spanish spirantization, as a lenition process, "too late". Spirantization is a regular process now, but perhaps there was an earlier stage, at the beginning of its conventionalization, where it operated more irregularly, affecting only certain frequent items, and did not apply across word boundaries. To get at the nature of lenitive changes we may need to examine processes at an earlier stage in their conventionalization. In the rest of the paper we turn our attention to the lenition of /ptk/ in Spanish.

## 3. Ongoing incipient lenition of intervocalic /ptk/ in Spanish: Methods

A number of studies on spontaneous speech have shown that in intervocalic position phonological /ptk/ are somewhat frequently realized as voiced in some Spanish dialects. This phenomenon has been reported for the Spanish of several geographical areas, including the Canary Islands (Trujillo 1980; Oftedal 1985), several areas of the Iberian Peninsula (Torreblanca 1976, 1979; Machuca Ayuso 1997; Lewis 2001; Martínez Celdrán 2009) and the Caribbean (Guitart 1978). The voicing process appears to be particularly frequent in Cuban and Canary Island Spanish.[7]

As our source of data we have used a corpus of high-quality recordings of both unscripted and scripted speech from the same 20 native speakers of Spanish, which was previously recorded in Majorca, Spain, for a different study (Simonet 2008). The 20 speakers are balanced by gender and equally divided between two groups by age (younger vs. older adults). Although Majorca is a bilingual Spanish/Catalan area, our speakers are all strongly dominant in Spanish. This was assessed through a language background questionnaire and a measure of speech proficiency using continuous accent ratings (Simonet 2010). The subjects were recorded in a quiet room with a solid-state digital recorder (Marantz PMD660) through a dynamic head-mounted microphone (Shure SM10A). The signal was digitized at 44.1 kHz and later down-sampled at 22.05 kHz using Praat (Boersma 2001).

The unscripted or spontaneous speech part of the corpus is drawn from a twenty-question game where the participant must guess the identity of a famous person by asking twenty questions. The participants interacted with one of the researchers, a native speaker of the language who grew up in the community. This provided from five to ten minutes of speech per participant. The scripted part of the corpus is from the reading of meaningful sentences. The expectation is that, if the voicing of /ptk/ is a sound change in its initial stages, it will be more common in unscripted than in scripted speech, unlike the more advanced and fully established spirantization of /bdg/, which, as mentioned, operates systematically across styles.

Notice that, since intervocalic /bdg/ are approximants in Spanish, the voiced realization of /ptk/ does not necessarily imply phonological merger. We then carry out an acoustic analysis intended to determine the degree of weakening, especially among voiced tokens of /ptk/, and the degree of overlap of voiced realizations of /ptk/ with phonemic /bdg/ in different contexts. For this, we consider three acoustic correlates of degree of constriction, in addition to consonant duration.

In our corpus, all instances of intervocalic phonological /ptk/ and /bdg/ were manually segmented and further analyzed with Praat (Boersma 2001). Within "intervocalic" we include the context between a vowel and a liquid, since this is also a context of voicing in the Western Romance sound change (e.g. Lat. PATRE > Sp. *padre* 'father'). Segmented consonants were labeled phonologically as /ptkbdg/. In the case of /ptk/, three allophones were given distinct labels on a different tier: "voiced" if there was uninterrupted voicing throughout the consonant, as revealed by F0 tracking; "partially voiced" if there was voicing during most of the duration of the consonant but the F0 tracker detected some interruption of voicing; and "voiceless" otherwise, including segments with some degree of voicing that did not extend over more than half of the duration of the consonant. That is, we have been conservative in classifying tokens of /ptk/ as voiced or partially voiced. On a third tier, we wrote the word in which the token consonant appeared and, in the case of word-initial tokens, the immediately preceding context.

The beginning and end of voiced and voiceless stops was determined by using the waveform and spectrogram. For voiceless stops, the beginning was marked at the end of the periodic cycles of the vowel, as shown in the waveform. The end point was placed just before the release burst of the consonant. In case there was no visible release burst, the mark was placed at the beginning of periodic oscillation for the vowel. For the segmentation of voiced consonants, a mark indicating the beginning was placed when the spectrogram revealed less intensity (lighter shades at all frequencies). The intensity curve displayed by Praat was used to verify the location of voiced approximants (it typically revealed a slight dip in intensity). An increase of amplitude in the waveform was taken as the beginning of the vowel and, hence, the end of the consonant.

We performed two types of analyses. The first analysis is based simply on counting the frequency of occurrence of each allophone of /ptk/ in the contexts of interest. This allows us to answer questions such as whether voicing is more frequent in some contexts than in others and whether there are any differences in frequency of voicing depending on the place of articulation of the consonant. The second analysis is an investigation of the acoustic correlates just discussed.

Visual inspection of spectrograms is enough to reveal that, in fact, most of the time, when /ptk/ are voiced they are also realized as continuants, just like phonological /bdg/. Nevertheless, it could be that the two phonological series differ in their degree of constriction or gestural magnitude. Determining this point is important in order to establish whether the stage is actually set for the potential recategorization of lexical items with phonological /ptk/ as containing /bdg/.

Intensity contours were generated using Praat (minimum pitch = 100 Hz, time step = 0.001 s). Mean intensity was subtracted from the contours. Praat's "To Intensity . . ." function calculates the square of the intensity values in the sound and then convolves them with a Gaussian analysis window. The duration of the analysis window was 32 ms. Intensity minima and maxima were hand-located by plotting the synchronous intensity contour, wave form and spectrogram of each target consonant. Intensity values were extracted from each landmark through cubic interpolation. Subsequently, intensity contours were first-differenced (time step = 0.001 s) and smoothed through low-pass filtering. The pass Hann band filter was given a floor of 0 Hz and a ceiling of 50 Hz and used a smoothing coefficient of 5 Hz above the ceiling.

Three measurements were derived from the intensity contour. The first measurement (i.e., IntDiff) is the difference between the intensity minimum during the consonant and the intensity maximum in the following tautosyllabic vowel. The more lenited the consonant, the smaller the difference in intensity will be expected to be with respect to the following vowel. The second parameter (IntRatio) is the result of dividing the intensity minimum by the intensity maximum. Measurements of relative intensity have been used in other studies of degree of constriction in voiced obstruents in Spanish, including Soler and Romero (1999), Cole et al. (1999), Lavoie (2001), Ortega-Llebaria (2004), Carrasco (2008), Eddington (2009) and Colantoni and Marinescu (2010).

The third measurement of degree of constriction, tested in Hualde et al. (2010), is MaxVel. This measurement is adapted from Kingston (2008), and is based on the observation that approximants have a more gradual transition to the following vowel than stops. For this correlate, the first difference of the intensity contour is used. MaxVel is found between the intensity minimum corresponding to the consonant and the maximum corresponding to the following vowel; that is, during the consonant-to-vowel transition. The maximum of the first difference indicates the maximum rising velocity between the midpoint of the consonant and the midpoint of the following vowel. This measurement reduces possible effects of variation in the intensity of the vowel and focuses on the abruptness of the transition between consonant and vowel. More lenited consonants have a less abrupt transition irrespective of the time from the intensity minimum to the intensity maximum.

Parrell (2010) recently compared articulatory (EMA) data with versions of our three acoustic parameters. It was found, for a limited set of controlled data and only for /b/, that the best of the three parameters (i.e. the one that most strongly correlated with articulatory data) is IntRatio, with IntDiff and MaxVel faring only slightly worse. Hualde et al. (2010) found, for spontaneous speech data and for Catalan /b, v, d, g/, that IntDiff and MaxVel provided reasonable, robustly correlated results. Since the articulatory-to-acoustic mapping of consonantal constriction degree is not well understood (and since we were to investigate highly variable spontaneous speech data), we decided to take a multiparametric approach and thus use several acoustic procedures. In addition to our three intensity-based measurements, we also measure the duration of the consonant closure, since voiceless stops have a longer constriction than voiced stops (and since lenition of intervocalic stops has been characterized as primarily involving decreased duration [Lavoie 2001; Blevins 2004: 147]). We want to know whether /ptk/ when realized as voiced still maintain greater duration than /bdg/.

Correlation analyses showed that all three intensity-based acoustic metrics were highly correlated with each other: IntDiff-IntRatio ($r = 0.987$), IntDiff-MaxVel ($r = 0.903$), IntRatio-MaxVel (r = 0.904). On the other hand, correlation analyses between duration (ms) and the three intensity-based metrics yielded *r*-values between 0.49 and 0.54.

In the next sections we address the three questions that we asked at the end of section 2 separately, presenting and discussing the data that are relevant to each of the questions.

## 4. How does phonological recategorization take place?

Our first question is whether our data on the voicing of intervocalic /ptk/ can offer us any light on the issue of how phonological recategorization takes place in sound change.

### 4.1. *Results (part I): Frequency of voicing of intervocalic /ptk/*

In Table 4 we offer the distribution of voiceless, partially voiced and fully voiced allophones of intervocalic /ptk/ in the spontaneous speech corpus. As can be seen, 22% of all tokens of intervocalic /ptk/ in spontaneous style are fully voiced, and the percentage of voiced productions reaches 35.7% if we count both fully and

Table 4. *Voiceless, voiced and partially voiced tokens of Spanish /ptk/ in the spontaneous speech corpus*

| | voiceless | partially voiced | voiced | TOTAL |
|---|---|---|---|---|
| p | 69 | 30 | 27 | 126 |
| t | 117 | 23 | 28 | 168 |
| k | 120 | 12 | 50 | 182 |
| TOTAL | 306 (64.2%) | 65 (13.6%) | 105 (22%) | 476 |

Table 5. *Voiceless, voiced and partially voiced tokens of Spanish /ptk/ in the read speech corpus*

| | voiceless | partially voiced | voiced | TOTAL |
|---|---|---|---|---|
| p | 1316 | 3 | 23 | 1342 |
| t | 2121 | 2 | 57 | 2180 |
| k | 910 | 0 | 82 | 992 |
| TOTAL | 4347 (96.3%) | 5 (0.1%) | 162 (3.6%) | 4514 |

partially voiced tokens. In Machuca Ayuso's (1997) study, the percentage of voiced tokens of /ptk/ is somewhat higher, ranging from 34.9% for one of her four subjects to 64.6% for another subject. The difference may have to do in part with our more strict definition of voicing, but also with the great variability among speakers in the use of voiced allophones that we also find in our data. If we group voiced and partially voiced realizations, four of our twenty speakers have over 60% partially or fully voiced productions.

The corpus of read speech yielded a much higher number of analyzable tokens of /ptk/, 4514 (vs. 479 in spontaneous speech). However, the percentage of voiced tokens of these phonemes is much lower, 3.6%, and there are extremely few partially voiced tokens (See Table 5). Voicing of /ptk/ is thus clearly a much more frequent phenomenon in spontaneous speech than in read speech.

Although optional, very infrequent in read speech and showing great inter-speaker variation, the voicing of /ptk/ is already conventionalized to some extent. An indication of this is that in the entire corpus, we found only one token of a phonemic voiceless stop realized as a voiceless fricative. This was a token of *poco* [poxo] 'little' in spontaneous style. Of the two common options for the lenition of voiceless stops, their voicing or their fricativization, the voicing option has already been conventionalized as a casual speech rule in the language.

### 4.2. *Results (part II): Acoustic analysis of degree of constriction*

The results presented in this section are based exclusively on the spontaneous speech data. The data from read speech are here excluded in order to obtain a more balanced data set. Data from read speech will be added in subsequent analyses.

Since the crucial comparison to determine the degree of phonological merger or overlap is between fully voiced tokens of /ptk/ and tokens of underlying /bdg/, for this analysis partially voiced tokens have been added to the voiceless category. A few tokens have been excluded because of obvious errors in the results from the analysis of the intensity curve. This has resulted in 476 tokens of intervocalic /ptk/, including 371 tokens of voiceless (and partially voiced) realizations and 105 tokens of fully voiced realizations. These are compared to 321 tokens of intervocalic underlying /bdg/ from the same corpus. We thus have a total of 797 tokens acoustically analyzed for which results are presented in the following subsections. A classification of the three allophones as a function of place of articulation is as follows: velars (u-voiced /g/ = 37 tokens, voiced /k/ = 50 tokens, voiceless /k/ = 132 tokens), labials (u-voiced /b/ = 131 tokens, voiced /p/ = 27 tokens, voiceless /p/ = 99 tokens), coronals (u-voiced /d/ = 153 tokens, voiced /t/ = 28 tokens, voiceless /t/ = 140 tokens).

4.2.1. *Intensity difference (Spanish spontaneous speech).* The results of the IntDiff calculation are shown in boxplots for voiceless (including partially voiced) and voiced realizations of /ptk/ as well as underlying /bdg/ (u-voiced) in Figure 1. The figure includes three panels, one for each place of articulation. Dark circles represent mean values while grey boxes show the interquartile range, i.e. data between the first quartile (the 25$^{th}$ percentile) and the third quartile (the 75th percentile). The 'whiskers' extend to the most extreme of the data points which lie no further away than 0.5 times the length of the box (R Documentation, version 2.9.2). Outliers beyond that range are not shown.

For all three places of articulation, IntDiff is greater for voiceless tokens of /ptk/ than for voiced tokens of the same phoneme, and it appears to be smallest for underlying /bdg/. The differences in IntDiff between the three sound categories (u-voiced, voiced, voiceless) appear to vary as a function of place of articulation. For instance, while there seems to be a scalar progression of u-voiced, voiced and voiceless (from most lenited to most constricted realizations) in the case of coronal and labial consonants, voiced allophones of /k/ appear to overlap more with /g/ than with voiceless allophones of /k/.

For the statistical analysis, the data were submitted to a mixed-effects regression model with IntDiff as response, individual speaker and word item as random intercepts and place of articulation (velar, coronal, bilabial) and voicing type (u-voiced, voiced, voiceless) as fixed factors (see Baayen 2008: Ch. 7). An ANOVA summary of the model yielded significant effects of voicing ($F[2,788] = 977.65$, $p < 0.001$) and place of articulation ($F[2,788] = 6.28$, $p = 0.001$), as well as a significant interaction ($F[4,788] = 4.96$, $p < 0.001$) between the two predictors. The fixed effect of voicing was explored in two regression models, each with a different intercept, and one single fixed factor, voicing type (u-voiced, voiced, voiceless). The two intercepts allowed us to test for the three target pairwise comparisons. Corresponding $p$-values were obtained through Markov Chain Monte Carlo sampling, calcu-

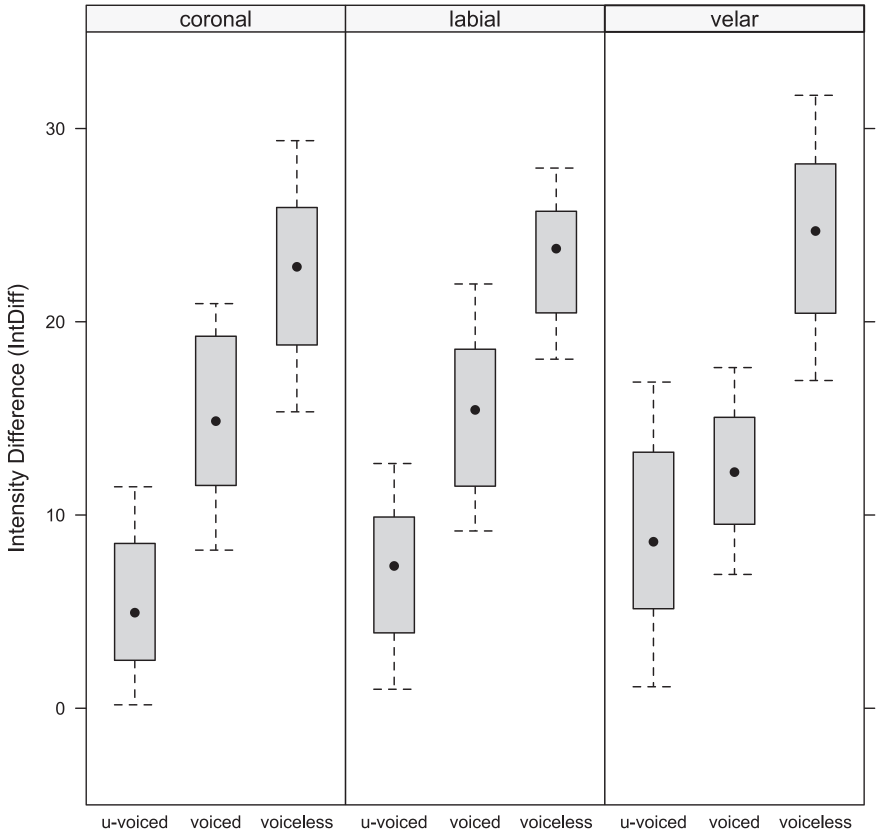


Figure 1. *Boxplots of intensity difference (IntDiff) between intensity in the consonantal minimum and intensity in the vocalic maximum of /ptk/ (realized as voiceless or voiced allophones) and /bdg/ (u-voiced) as a function of place of articulation (velar /kg/, coronal /td/, bilabial /pb/).*

lated on the *t*-statistic (Baayen 2008: 270). Subsequently, the dataset was divided as a function of place of articulation and two regression analyses (assuming two different intercepts) were carried out for each subset. This was done in order to explore the interactions between voicing type and place of articulation. The results are provided in Table 6.

The statistical analyses revealed that, with regards to IntDiff, all three types of voicing realizations (u-voiced /bdg/, voiced /ptk/ and voiceless /ptk/) differed from each other for all three places of articulation. The smallest difference between means was that between underlyingly voiced /g/ and voiced /k/. In sum, voiced realizations of /ptk/ are significantly more lenited than voiceless realizations of these phonemes as well as more constricted than underlyingly voiced /bdg/.

Table 6. *Mixed-effects regression analyses of IntDiff as a function of voicing type (u-voiced /bdg/, voiced /ptk/, voiceless /ptk/) with speaker and word as random intercepts.*

| Analysis | Intercept | Comparison | beta-value | t-value | p-value |
|---|---|---|---|---|---|
| All data | /bdg/ | Voiced /ptk/ | 8.75 | 14.34 | <0.001 |
| | | V'less /ptk/ | 16.36 | 39.77 | <0.001 |
| | V'less /ptk/ | Voiced /ptk/ | −7.6 | −13.4 | <0.001 |
| Velars | /g/ | Voiced /k/ | 4.14 | 3.55 | <0.001 |
| | | V'less / k/ | 14.42 | 14.6 | <0.001 |
| | V'less /k/ | Voiced /k/ | −10.28 | −10.76 | <0.001 |
| Coronals | /d/ | Voiced /t/ | 10.75 | 10.51 | <0.001 |
| | | V'less /t/ | 16.59 | 26.18 | <0.001 |
| | V'less /t/ | Voiced /t/ | −5.83 | −6.06 | <0.001 |
| Labials | /b/ | Voiced /p/ | 9.66 | 8.57 | <0.001 |
| | | V'less /p/ | 16.38 | 22.15 | <0.001 |
| | V'less /p/ | Voiced /p/ | −6.71 | −6.57 | <0.001 |

4.2.2. *Intensity ratio (Spanish spontaneous speech).* The IntRatio data are shown in the boxplots in Figure 2. A cursory inspection of the boxplots suggests a pattern very similar to the one revealed by the IntDiff measure. In this particular case, voiced and voiceless realizations of /t/ and /p/ are more similar to each other than to /d/ and /b/, respectively. On the other hand, voiced realizations of /k/ appear to be more similar to /g/ tokens than to voiceless realizations of /k/.

We first explored the data by submitting them to a mixed-effects regression model followed by an ANOVA summary with IntRatio as response, speaker and word as random intercepts and voicing type (u-voiced, voiced, voiceless) and place of articulation (velar, coronal, bilabial) as fixed factors. The model yielded significant effects of both voicing type ($F[2,788] = 1{,}194.54$, $p < 0.001$) and place of articulation ($F[2,788] = 4.99$, $p = 0.01$) and a significant interaction ($F[4,788] = 5.46$, $p < 0.001$).

Pairwise comparisons were carried out by replicating the regression models with a different intercept. The interaction between the two predictors was investigated by dividing the data into three datasets, as a function of the place of articulation of the consonants. The results show, once again, that voiced realizations of /ptk/ are significantly more constricted than voiced /bdg/ and significantly more lenited than voiceless tokens of /ptk/. The greatest similarity between two different distributions was that between /g/ and voiced /k/. See Table 7.

4.2.3. *Maximum rising velocity (Spanish spontaneous speech).* The MaxVel data are shown in the boxplots in Figure 3. The MaxVel data suggest that voiced and voiceless tokens of /t/ greatly overlap while they robustly differ from /d/. For the velars, there seems to be a greater overlap between /g/ and voiced realizations of /k/ than between the latter and voiceless tokens of /k/. The case of the labials shows a scalar progression of u-voiced, voiced, voiceless.

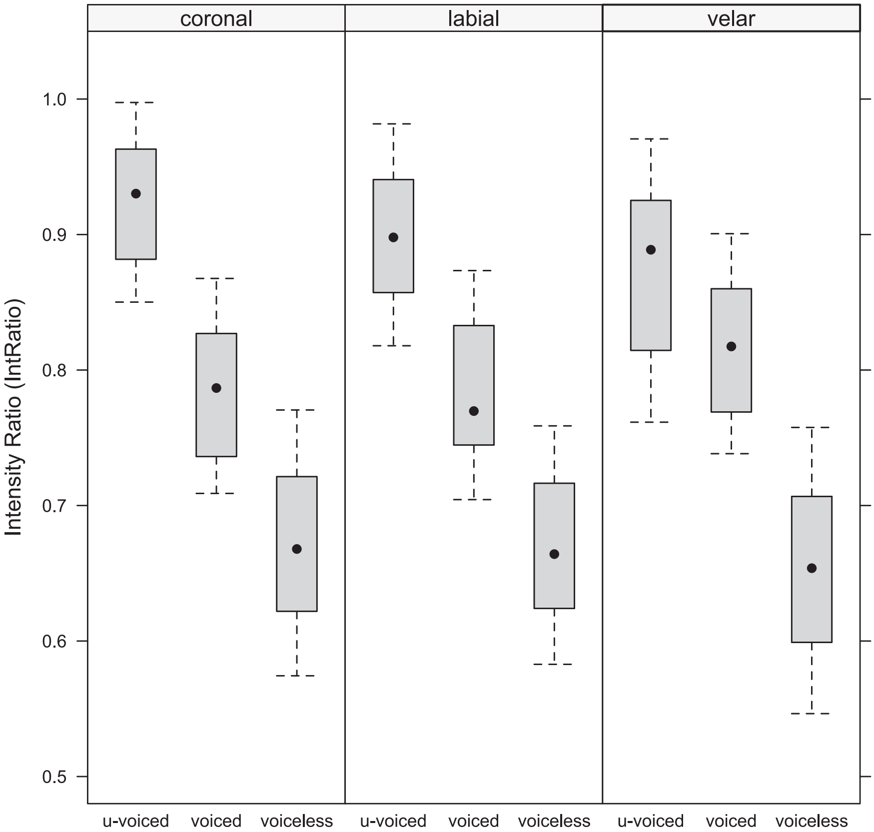


Figure 2. *Boxplots of intensity ratio (IntRatio) in the intensity trajectory between the consonantal minimum and the vocalic maximum of /ptk/ (realized as voiceless or voiced allophones) and /bdg/ (u-voiced) as a function of place of articulation (velar /kg/, coronal /td/, bilabial /pb/).*

We used mixed-effects regression with MaxVel as response, speaker and word as random intercepts and voicing type (u-voiced, voiced, voiceless) and place of articulation (velar, coronal, bilabial) as fixed factors. An ANOVA summary of the model yielded significant effects of both voicing type ($F[2,788] = 758.15$, $p < 0.001$) and place of articulation ($F[2,788] = 5.0$, $p < 0.001$), as well as a significant interaction between the two ($F[4,788] = 9.96$, $p < 0.001$). The statistical tests show that voiced tokens of /ptk/ differ in constriction degree from both /bdg/ and voiceless realizations of /ptk/. See Table 8.

4.2.4. *Duration (Spanish spontaneous speech).* The duration (excluding release) of the consonants in our three categories, further divided by place of articulation, is shown in boxplots in Figure 4. The first exploration of the data consisted in

Table 7. *Mixed-effects regression analyses of IntRatio as a function of voicing type (u-voiced /bdg/, voiced /ptk/, voiceless /ptk/) with speaker and word as random intercepts.*

| Analysis | Intercept | Comparison | beta-value | t-value | p-value |
|---|---|---|---|---|---|
| All data | /bdg/ | Voiced /ptk/ | −0.12 | −15.29 | <0.001 |
| | | V'less /ptk/ | −0.23 | −43.61 | <0.001 |
| | V'less /ptk/ | Voiced /ptk/ | 0.11 | 15.22 | <0.001 |
| Velars | /g/ | Voiced /k/ | −0.06 | −4.13 | <0.001 |
| | | V'less /k/ | −0.21 | −16.39 | <0.001 |
| | V'less /k/ | Voiced /k/ | 0.14 | 11.87 | <0.001 |
| Coronals | /d/ | Voiced /t/ | −0.14 | −11.14 | <0.001 |
| | | V'less /t/ | −0.24 | −30.18 | <0.001 |
| | V'less /t/ | Voiced /t/ | 0.09 | 7.19 | <0.001 |
| Labials | /b/ | Voiced /p/ | −0.13 | −9.43 | <0.001 |
| | | V'less /p/ | −0.23 | −24.2 | <0.001 |
| | V'less /p/ | Voiced /p/ | 0.09 | 7.27 | <0.001 |

submitting them to a mixed-effects regression analysis followed by an ANOVA summary of the results. For this analysis, duration (ms) was used as response, individual speaker and word were used as random intercepts, and voicing type (u-voiced, voiced, voiceless) and place of articulation (velar, coronal, bilabial) were used as fixed factors. The model resulted in significant fixed effects of both voicing type ($F[2,788] = 93.01$, $p < 0.001$) and place of articulation ($F[2,788] = 7.98$, $p < 0.01$) and a significant interaction between the two factors ($F[4,788] = 3.90$, $p < 0.01$).

The analysis of duration patterns as a function of place of articulation and voicing type is shown in Table 9. The three pairwise comparisons reach significance for the three consonants when pooled together. Underlyingly voiced /g/ did not differ in duration from voiced /k/, while voiced /k/ differed from voiceless /k/. The three coronal consonant types (u-voiced /d/, voiced /t/, voiceless /t/) differed from each other, in a scalar progression. Finally, voiced /p/ did not differ from voiceless /p/ while they both differed from underlyingly voiced /b/. To summarize, the voiced tokens were found to pattern with the u-voiced consonants in the case of the velar sounds but with the voiceless tokens in the case of the bilabial consonants.

### 4.3. *Conclusions on recategorization*

Our analysis has revealed that even though intervocalic /ptk/ are voiced with some frequency in unscripted Spanish speech, we cannot speak of merger with /bdg/ in this language, since the two phonological series differ in constriction degree and duration even when /ptk/ are fully voiced (see also Romero et al. 2007). The smallest difference between voiced tokens of underlyingly voiceless consonants and underlyingly voiced ones was found in the case of the velars.

To understand phonological recategorization in sound change we need to have an understanding of the nature of phonological categories at any given stage. Our

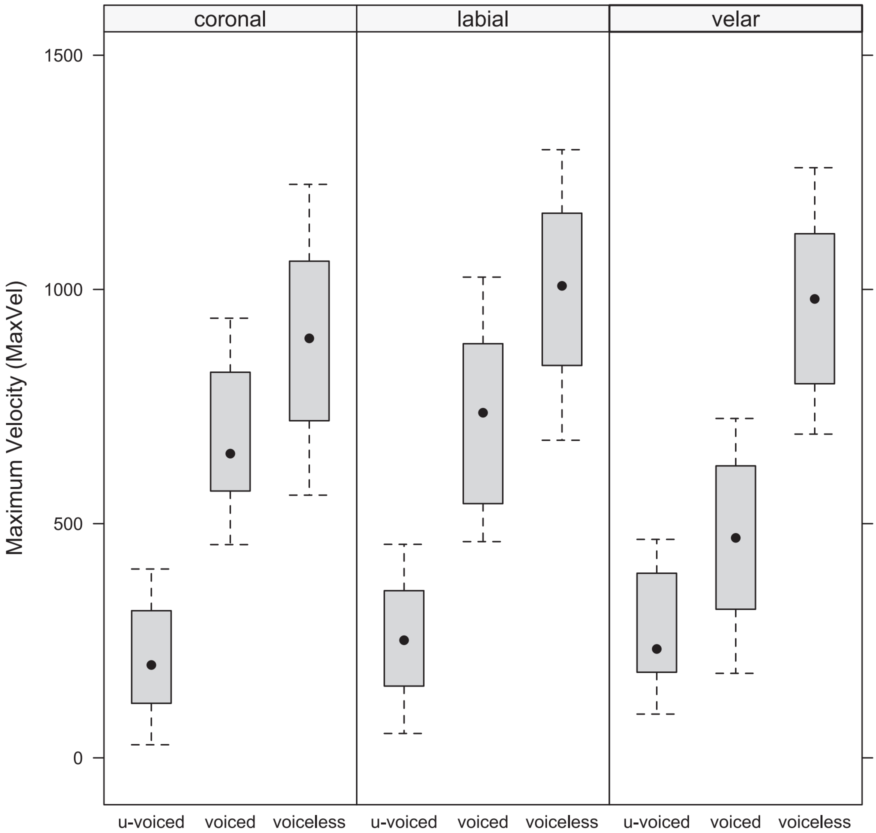


Figure 3. *Boxplots of maximum rising velocity (MaxVel) in the intensity trajectory between the consonantal minimum and the vocalic maximum of /ptk/ (realized as voiceless or voiced allophones) and /bdg/ (u-voiced) as a function of place of articulation (velar /kg/, coronal /td/, bilabial /pb/).*

analysis has revealed that, in intervocalic position, /ptk/ and /bdg/ in Spanish have distinct but partially overlapping ranges.

Phonemic /-k-/ includes both voiceless and voiced/spirantized realizations, but most realizations are still voiceless and, even when voiced and spirantized, tokens of /-k-/ tend to be somewhat more constricted than tokens of /-g-/, as revealed by our acoustic measurements. In the case of the other two places of articulation, the difference between voiced realizations of the two phonemic categories is greater and there is also a durational difference between the voiced realizations of phonologically voiceless consonants and the underlyingly voiced consonants. Individual tokens of voiced /ptk/ may, nevertheless, fall within the range of /bdg/, especially for the velars.

Table 8. *Mixed-effects regression analyses of MaxVel as a function of voicing type (u-voiced /bdg/, voiced /ptk/, voiceless /ptk/) with speaker and word as random intercepts.*

| Analysis | Intercept | Comparison | beta-value | t-value | p-value |
|---|---|---|---|---|---|
| All data | /bdg/ | Voiced /ptk/ | 402.69 | 14.66 | <0.001 |
| | | V'less /ptk/ | 691.79 | 36.71 | <0.001 |
| | V'less /ptk/ | Voiced /ptk/ | −289.1 | −11.69 | <0.001 |
| Velars | /g/ | Voiced /k/ | 161.91 | 3.03 | <0.01 |
| | | V'less /k/ | 601.41 | 13.22 | <0.001 |
| | V'less /k/ | Voiced /k/ | −439.5 | −10.71 | <0.001 |
| Coronals | /d/ | Voiced /t/ | 495.77 | 10.79 | <0.001 |
| | | V'less /t/ | 664.91 | 24.22 | <0.001 |
| | V'less /t/ | Voiced /t/ | −169.14 | −3.78 | <0.001 |
| Labials | /b/ | Voiced /p/ | 558.51 | 12.09 | <0.001 |
| | | V'less /p/ | 775.96 | 24.54 | <0.001 |
| | V'less /p/ | Voiced /p/ | −217.45 | −5.49 | <0.001 |

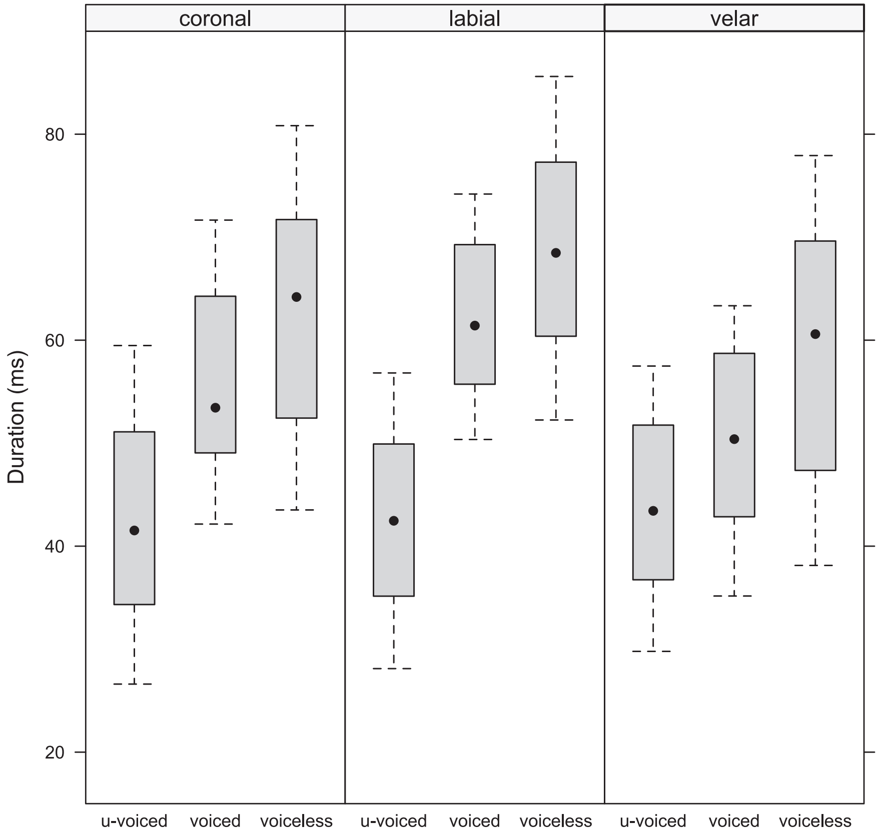


Figure 4. *Boxplots of duration (ms) of /ptk/ (realized as voiceless or voiced allophones) and /bdg/ (u-voiced) as a function of place of articulation (velar /kg/, coronal /td/, bilabial /pb/).*

Table 9. *Mixed-effects regression analyses of duration (ms) as a function of voicing type (u-voiced /bdg/, voiced /ptk/, voiceless /ptk/) with speaker and word as random intercepts.*

| Analysis | Intercept | Comparison | beta-value | t-value | p-value |
|---|---|---|---|---|---|
| All data | /bdg/ | Voiced /ptk/ | 10.86 | 5.29 | <0.001 |
| | | /ptk/ | 19.06 | 13.65 | <0.001 |
| | /ptk/ | Voiced /ptk/ | −8.2 | −4.33 | <0.001 |
| Velars | /g/ | Voiced /k/ | 6.16 | 1.61 | >0.1 |
| | | V'less /k/ | 14.57 | 4.47 | <0.001 |
| | V'less /k/ | Voiced /k/ | −8.4 | −2.88 | <0.01 |
| Coronals | /d/ | Voiced /t/ | 8.82 | 2.34 | <0.05 |
| | | V'less /t/ | 17.54 | 7.65 | <0.001 |
| | V'less /t/ | Voiced /t/ | −8.71 | −2.42 | <0.05 |
| Labials | /b/ | Voiced /p/ | 20.77 | 6.03 | <0.001 |
| | | V'less /p/ | 25.86 | 10.82 | <0.001 |
| | V'less /p/ | Voiced /p/ | −5.09 | −1.7 | >0.05 |

Table 10. *Spanish spontaneous speech: word-initial vs. medial /ptk/*

| | voiceless | partially voiced | voiced | TOTAL |
|---|---|---|---|---|
| initial | 100 (62.8%) | 19 (11.9%) | 40 (25.1%) | 159 |
| medial | 206 (64.9%) | 46 (14.5%) | 65 (20.5%) | 317 |
| TOTAL | 306 | 65 | 105 | 476 |

## 5. Is lenition restricted to word-internal contexts at the initial stages of the process?

In Table 10 the data from our Spanish spontaneous speech corpus are separated by position. It is obvious that word boundaries do not prevent the voicing of intervocalic stops. The percentage of word-initial intervocalic /ptk/ that are voiced is in fact somewhat higher than the percentage of word-medial tokens of these phonemes that are voiced (25.1% word-initial vs. 20.6% word-medial). From these data we can already answer the question of whether, at this early stage in the process, the voicing of stops is restricted to the word-internal context. The answer is negative: Voicing takes places equally inside words and across word-boundaries, as long as the target segment is in the intervocalic context. Similarly, of the 158 tokens of voiced intervocalic /ptk/ that we have obtained in reading style, 79 are word initial and 79 are word medial.

As a reviewer points out, the voicing of word-initial /ptk/ after a vowel may be conditioned by the strength of the prosodic boundary between the two words. From our results we can conclude that at least some prosodic boundaries do not prevent voicing. This is the most relevant point since, as mentioned before, in the Western Romance voicing of intervocalic stops and in similar sound changes, the change was limited to the word-internal context.

To test the influence of a preceding word boundary on lenition, we have pooled together the tokens of voiced /ptk/ from both the spontaneous and read speech data sets and submitted them to a two-factor statistical analysis for each of our acoustic parameters of lenition, IntDiff, IntRatio, MaxVel and duration. The data were fitted using mixed-effects regression with speaker and lexical item as random intercepts and word-position (initial [119 tokens], medial [144 tokens]) and place of articulation (velar [131 tokens; 66 initial and 65 medial], coronal [83 tokens; 21 initial and 62 medial], labial [49 tokens; 32 initial and 17 medial]) as fixed effects.

The results of the statistical tests revealed, for IntDiff, no effects of position ($F[1,257] = 0.85, p > 0.1$) or of place ($F[2,257] = 0.88, p > 0.1$) and no significant interaction ($F[2,257] = 1.75, p > 0.1$). Regarding IntRatio, the model yielded non-significant effects of position ($F[1,257] = 1.35, p > 0.1$), no effects of place ($F[2,257] = 0.93, p > 0.1$), and a marginally non-significant interaction ($F[2,257] = 2.96, p = 0.054$). MaxVel data were submitted to an identical statistical analysis, which revealed no effects of position ($F[1,257] = 0.56, p > 0.1$), significant effects of place of articulation ($F[2,257] = 7.55, p < 0.001$), and no interaction ($F[2,257] = 1.6, p > 0.1$). The place of articulation effects were due to the fact that voiced /k/ differed significantly from the other two consonants while voiced /t/ and voiced /p/ did not differ from each other. (This effect may be observed in Figure 3). In particular, voiced /k/ had a much lower MaxVel value than the other two consonants (e.g. $\beta = -206.05, t = -2.87$ *vs.* voiced /t/). Finally, duration (ms) data yielded significant place of articulation effects ($F[2,257] = 14.84, p < 0.001$), but no effects of position ($F[1,257] = 2.37, p = 0.1$) and no interaction ($F[2,257] = 2.91, p = 0.1$). Voiced /p/ tokens were found to be significantly longer than the other two consonants (e.g. $\beta = 15.23, t = 3.84$ *vs.* voiced /t/). (This effect may be observed in Figure 4.)

To summarize, the comparison between word-initial and word-medial tokens of intervocalic /ptk/ yielded no significant results for any of the four acoustic parameters. Only place of articulation effects were found, and only for two of the four acoustic measures.

For comparison, we consider now the influence of a preceding word boundary on the realization of underlying /bdg/. The data are from our spontaneous speech corpus which contains 321 analyzed tokens of these consonants in intervocalic position, 72 in word-initial position and 249 in word-medial position. Mixed-effects regression was used. In the models, speaker and word were used as random intercepts, and word-position (initial, medial) and place of articulation (coronal, labial, velar) were fixed factors. No effects of position (and no interactions) were found for IntDiff (medial, $\beta = -1.91, t = -1.88$), IntRatio (medial, $\beta = 0.02, t = 1.78$) or MaxVel (medial, $\beta = -57.74, t = -1.34$). Finally, a significant difference between /bdg/ tokens in word-initial and word-medial position was found with respect to their duration (medial, $\beta = -8.59, t = -2.83, p < 0.01$). Note that this difference, although significant, was of only approximately 8.5 ms. Functionally equivalent results were found when word-medial and word-initial tokens of voiceless /ptk/ were compared using our four acoustic parameters.

As we can observe, voiced /ptk/ show the same pattern as underlying /bdg/ (and voiceless /ptk/) regarding the influence of a preceding word boundary. In neither case is there strong evidence for greater lenition inside words than across word boundaries.

## 6. Discussion (part I): Model of sound change

From the results that we have obtained in our analysis of the incipient voicing of intervocalic stops in Spanish, it seems unlikely that there could be a systematic recategorization and merging of /ptk/ with /bdg/ in the near future, since, although /ptk/ are sometimes voiced and spirantized, the overlap between the two phonemic categories is very limited when we consider the degree of constriction of voiced tokens of /ptk/. It would be, however, possible for recategorization to take place in specific lexical items, especially for the velars, where the overlap between phonemes is greatest.

Consider the possible recategorization of words in /-iko/ (and /-ika/) with antepenultimate stress. In our data, /k/ is very frequently voiced in words ending in /-iko/ (*política*, *físico, médico, asiático, hispánica*). In our interpretation of the facts, it is possible for a speaker to have acquired two categorically different underlying representations for a number of lexical items, say, /médiko/ and /médigo/ for *médico*. Whichever form s/he chooses in a given utterance, its online implementation will depend on prosodic factors, such as whether or not the word receives a pitch accent, and not on anything specific about this particular word.[8]

Relevantly, for the less common ending /-igo/, /-iga/ (*vértigo* 'vertigo', *pértiga* 'pole') a search in Google (Spanish-language pages) reveals hypercorrected forms **vértico*, **pértica*. This suggests that words with prestressing *-ico* /-iko/ may have indeed acquired a rephonologized variant in /-igo/ for some speakers, which creates uncertainty in the case of the smaller number of words containing *-igo* in the standard spelling as to whether they may belong to this class. (For Central Catalan, a 19th century manuscript entitled *Llibre de politigas* 'book of policies' [Lleal 1988] provides direct evidence for recategorization in this specific word.)

We suggest that, at this early stage, weakening may affect intervocalic voiceless stops regardless of lexical frequency. Certain phonetic contexts, however, may favor a greater degree of lenition. It is words presenting these contexts that will be more likely to undergo recategorization in the way proposed by Ohala (1974, and elsewhere). Recategorization may then spread to other words with the same or similar phonetic context.

We can explain recategorization in these specific lexical items while still upholding the Neogrammarian hypothesis for the initial, phonetic, stage of the sound change. Lenition, operating without regard to lexical items, affects the phoneme

/k/ to a greater extent than /p/ and /t/, as we have seen.[9] Tokens in unstressed position will tend to be more weakened than those in the onset of stressed syllables, and those in the onset of the last syllable in proparoxytones (i.e. two syllables after the stress) may be particularly weak. In our Spanish spontaneous data we find that whereas 23.5% of tokens of /ptk/ in the onset of stressed syllables are fully or partially voiced, in unstressed syllables this percentage is 39.4%. The percentage of fully or partly voiced tokens in the onset of the last syllable of proparoxytones is even higher, reaching 44.2%. The ending /-iko/, /-ika/ happens to be by far the most frequent sequence where the phonological factors that favor lenition converge, which may lead to phonological recategorization in lexical items presenting this context.

It is also important to notice that the voicing-with-spirantization process is already conventionalized in the language as an optional rule in informal speech. Recall that, among thousands of tokens that were inspected, we found only one token of a voiceless fricative realization of an underlying voiceless stop in intervocalic position. In this respect, Spanish may be compared with Florentine Italian, where what has been conventionalized is the voiceless fricative realization of intervocalic /ptk/: *la pipa* [laɸi:ɸa] 'the pipe', *la casa* [laha:sa] 'the house', *data* [da:θa] 'given, fem.' (Canepari 1979: 214).

We believe we have evidence for a model of sound change where the online variable reduction and overlap of articulatory gestures in casual speech (see Browman and Goldstein 1991) is at some point conventionalized as a specific process of phonetic reduction. This conventionalization takes place as the Neogrammarians postulated: phonemes are affected in specific phonetic contexts. A crucial finding is that word-initial plosives, when preceded by a vowel, are as likely to be reduced as word-internal ones.

The conventionalization of the phonetics may later be followed by phonemic recategorization. This recategorization, on the other hand, would operate on specific lexical units, not on phonemes across-the-board.

This model of sound change is schematized in (2), where it is illustrated with the sound change /p/ > /b/ /V__V (Hualde 2011).

(2) Model of sound change
  a. "Online" effect: gesture reduction and overlap: /apa/ [apa] ~ [aba] (variable degree of voicing) ~ [aɸa] (variable closure)
  b. Conventionalization: /apa/ [aba]
  c. Phonemic recategorization: [aba] /-p-/ > [aba] /-b-/

The claim is thus that conventionalization is Neogrammarian, i.e., phonemes are affected; but recategorization is lexically gradual, i.e., words change. Conventionalized lenition processes apply across the board in a first stage. Lexical effects and word-boundary effects are produced by the recategorization of the most extreme variants generated by the lenition process. This recategorization may result in the same word having two alternative "underlying representations" for some time, so that original /apa/ (with variable reduction) and recategorized /aba/ may coexist (cf. Sp. /lado/ ~ /lao/ 'side'). The facts of the more advanced lenition of /bdg/ and the less advanced lenition of /ptk/ are fully compatible with this interpretation.

Phonological recategorization in sound change will tend to be all in the same direction, avoiding the hypothetical situation illustrated in (1), because it operates on the results of a previously conventionalized phonetic reduction process.[10] All words with the same sound in the same phonological context will tend to be reinterpreted in the same way to the extent that this reinterpretation operates on a previously conventionalized pattern of reduction.[11]

## 7. Discussion (part II): Consequences for our understanding of the Western Romance voicing of intervocalic stops

Our motivation in investigating on-going intervocalic stop lenition in Spanish was the possibility of gaining an understanding that would be applicable to accomplished regular sound changes such as the voicing of intervocalic stops in Western Romance.

There is one aspect where our results appear to be at odds with the Western Romance sound change: the occurrence of lenition across word boundaries, affecting word-initial consonants. Our results strongly suggest that the restriction of voicing to the word-internal context, as we find in the Western Romance sound change, rather than representing an original situation, is the result of later suppression of alternations in word-initial position, related to the recategorization of word-internal consonants, as argued by Weinrich (1958) and, after him, also by Hall (1964) and Cravens (2002).

In a number of Romance varieties outside of the Western Romance area, intervocalic stops are said to be partially voiced or lenited to various degrees. This phenomenon is found in many varieties of southern and central Italy, as well as in Corsican and Sardinian (Canepari 1979; Loporcaro 2009; Dalbera-Stefanaggi 1991; Jones 1997, etc. See Albano Leoni and Maturi 1991 for an instrumental study of a southern Italian variety). In all these Eastern Romance languages, lenition operates without regard to word boundaries.

As Weinrich (1958) points out, remarkably, the Western/Eastern Romance linguistic boundary is also the boundary for the application of lenition at the phrasal level: "Höchst bemerkenswert ist nämlich, daß die ost-westromanische Sprachgrenze gleichzeit als eine Grenze der Satzphonetik erscheint" ["Most remarkable is the fact that the Eastern/Western Romance linguistic boundary appears at the same time as a boundary for phrasal phonetics"] (Weinrich 1958: 47). Weinrich suggests that, at some earlier stage, the voicing of intervocalic /ptk/ in Western Romance should have affected word-initial segments as well and that, at a later stage, when intervocalic /ptk/ became recategorized as /bdg/, word-initial voiceless stops were restored by influence of the other tokens of the same word in postconsonantal or phrase-initial position (with very few exceptions, where phonologization resulted in word-initial voicing instead). Our data on the incipient "second round" of voicing that we find in Spanish support the position that at the initial stages of a weakening process only phonetic factors play a role. In particular, word boundaries do not prevent the operation of lenition.

We have also found evidence for different degrees of lenition related to place of articulation (and, perhaps, stress and other phonetic factors). We have suggested that, whereas conventionalized lenition processes apply across the board, recategorization as a different phoneme may take place on an item-by-item basis. If this is so, the regularity that we find in Western Romance in the word-internal context is likely to be the result of a gradual extension of this recategorization.

In the case of word-initial consonants, the recategorization of /ptk/ as /bdg/ would have been prevented in the case of word-initial consonants because of the pressure of tokens of the same word outside of the context of lenition, thus avoiding alternations of the type /kasa/ 'house' but /la gasa/ 'the house' for the same word, as Weinrich and others have maintained and in agreement with exemplar models of the lexicon.

Interestingly, most cases of sporadic voicing of word-initial stops in Romance involve /k-/ becoming /g-/ (Figge 1966). This is consistent with our finding of greater lenition of this consonant (see also Recasens 2002 on the preferential voicing of /k/ in Romance).

We also want to remark that voicing and spirantization are taking place simultaneously in present-day Spanish, unlike what we need to assume for the first round of voicing, at least in Ibero-Romance (since in some Portuguese varieties these segments are voiced stops), although it is possible than in French, where the lenition of Latin /ptk/ went further, voicing and spirantization were also coexisting processes.

To conclude, Spanish is undergoing an incipient process of voicing and spirantization of intervocalic voiceless stops. Given the great amount of variation among speakers in the frequency with which they implement this process, it is too early to tell whether the sound change will actually run its course. It may depend on social factors.

This lenition does not appear to be lexically restricted (among the most lenited tokens we find both high frequency and low frequency words). It also operates both within words and across word boundaries. In this it is not unlike the more advanced and fully conventionalized spirantization of the voiced stops.

We observe that, even when fully voiced and spirantized, /ptk/ tend to be more constricted than /bdg/ in the same position, so that there is no systematic phonemic merger. We found, nevertheless, some evidence that /k/ undergoes greater reduction than the other two consonants and that instances of certain endings containing this consonant may in fact be phonologically ambiguous, which could lead to their recategorization. Our conclusion is that this lenition process involves two stages. The first one is the conventionalization of a specific, purely phonetic weakening rule (in our case voicing-cum-spirantization). As a gradual phenomenon, lenition may affect certain sequences with greater intensity, potentially leading to recategorization, as we also see in the deletion of intervocalic voiced stops in present-day Spanish. This second process, phonological recategorization, affects specific lexical items and will therefore affect word-initial and word-internal segments differently. That is, recategorization at word boundaries may be blocked by pressure from tokens of the same word outside of the context of lenition. We thus find support for Weinrich's (1958) suggestion that the blocking of the sound change across word boundaries that we find in Western Romance voicing must be a secondary development, linked to rephonologization, after a first stage where phonetic voicing applied without regard to word boundaries.

Observing a regular sound change such as Western Romance voicing, one could reasonably entertain the hypothesis that, as an incipient phenomenon, it might have affected only word-internal tokens in high frequency words, other tokens remaining unaffected at first. Our results from the incipient second round of intervocalic voicing that we are witnessing in present-day Spanish do not support this hypothesis. The incipient optional lenition that we observe is not restricted to high-frequency items, nor is it prevented from applying across word boundaries. The facts are, however, compatible with the view that eventual phonemic recategorization may start with the most frequent words and collocations among those containing the phonetic subcontexts that favor the greatest degree of lenition.

Whereas many synchronic phonological rules of lenition, like the spirantization of /bdg/ in Spanish, apply across the board, in sound change we typically find restriction of the change to the word-internal domain, like in the Western Romance voicing of /ptk/ (and sometimes lexical irregularity). We suggest that lenition initially occurs both inside words and across word boundaries even if subsequent phonological recategorization takes place only within words. The hypothesis may be extended to other sound changes as well.

Correspondence e-mail address: jihualde@illinois.edu

## Notes

1. Following established tradition, the Latin ancestors of Romance words are generally given in the accusative form, without the final *-m* of the accusative singular, which was lost in pronunciation very early.
2. To give another example of different conventionalized choices in lenition patterns, the reduction process affecting /t/ in Liverpool English (affrication) is quite different from the phenomena of glottalization or flapping that we find in other dialects (Honeybone 2001).
3. For a phonological analysis of this phenomenon within Generative Phonology, see Harris (1969), Mascaró (1984), among others.
4. Notice that we are not claiming that in the analysis of phonetic records one will not find tokens where the consonant appears to be absent. The claim is, rather, that there is no conventionalized

variant of these words with a missing consonant, unlike what happens with participles in *-ado*, etc. That is, there is a /d/ target (on this see Ohala 1992).

5. We differ from a more classical phonemic view of underlying representations in accepting that a given word may have more than one categorically distinct articulatory plan or gestural score. In our view, the relevant fact in listeners' reinterpretation (à la Ohala) is the postulation of a novel underlying articulatory plan.
6. Although we do not have any direct evidence that spirantization must precede deletion we take this to follow from the common assumption that the weakening of a segment must precede its deletion.
7. Colantoni and Marinescu (2010), on the other hand, do not find evidence for the weakening of /ptk/ in a sample of Argentinean Spanish.
8. Findings such as those mentioned in Bybee (2002) for the deletion of word-final postconsonantal /t/ and /d/ in English are largely compatible with our view. Both high frequency and low frequency words appear to undergo this process, even if the variant without final /t/, /d/ is more commonly chosen with certain items. On the other hand, Bybee (2002) also suggests that there is a difference in the duration of these final consonants depending on word category and lexical frequency. This finding would not be compatible with our view. Our interpretation is that a conventionalized process of reduction of the final apical gesture in the relevant word-final position has resulted in speakers having two underlying representation for some words. For these items, the speaker may choose one or the other gestural score to implement. If the form with the underlying final apical gesture is chosen, we do not expect word-specific degrees of reduction, only context-specific effects.
9. This is consistent with the tendency in the history of the Romance languages to voice /k/ more readily than the two other voiceless stops (Recasens 2002). The possibly universal character of place effects in lenition processes is discussed in Foley (1977), but see Hyman (1975), Kirchner (2001). Ohala's Aerodynamic Voicing Constraint (Ohala 1983, 1997; Ohala and Riordan 1979) is primarily an explanation of place asymmetries in the devoicing and weakening of voiced stops. A reviewer points out that the fact that dorso-velar consonants involve tongue body gestures could lead to greater blending and overlap with adjacent vowels than what would be expected for coronals and labials.
10. Our view of sound change is, we believe, similar to that expressed by Labov (1981, 1994, 2006). Blevins' (2004: 32–33) Evolutionary Phonology model deals primarily with the stage we are calling "recategorization". As in her *chance* and *choice* types of sound change, we assume accurate perception on the part of the listener.
11. Sometimes more than one reduction process may compete for conventionalization. For instance, in some dialects of both Spanish (e.g. Dominican, Istanbul Judeo-Spanish) and Basque, [ɾ] competes with [ð] as the intervocalic realization of /d/. This competition between reductive strategies may produce irregularity in sound change, as has indeed happened in dialects of both languages.

## References

Albano Leoni, Federico & Pietro Maturi. 1991. Le occlusive sorde nell'italiano di Nusco. In Luciano Giannelli, Nicoletta Maraschio, Teresa Poggi Salani & Massimo Vedovelli (eds.), *Tra rinascimento e strutture attuali: Saggi di linguistica italiana*, 253–258. Torino: Rosenberg & Sellier.

Baayen, Harald. 2008. *Linguistic data analysis*. Cambridge: Cambridge University Press.

Blevins, Juliette. 2004. *Evolutionary phonology: The emergence of sound patterns*. Cambridge: Cambridge University Press.

Boersma, Paul. 2001. Praat, a system for doing phonetics by computer. *Glot International* 5(9/10). 341–345.

Browman, Catherine P. & Louis Goldstein. 1986. Towards an articulatory phonology. *Phonology Yearbook* 3. 219–252.

Browman, Catherine P. & Louis Goldstein. 1989. Articulatory gestures as phonological units. *Phonology* 6. 201–251.

Browman, Catherine P. & Louis Goldstein. 1991. Gestural structures: Distinctiveness, phonological processes and historical change. In Ignatius G. Mattingly & Michael Studdert-Kennedy (eds.), *Modularity and the motor theory of speech perception*, 313–338. Hillsdale, NJ: Lawrence Erlbaum Associates.

Brown, Gillian. 1977. *Listening to spoken English*. London: Longman.

Bybee, Joan. 2000. Lexicalization of sound change and alternating environments. In Michael Broe & Janet Pierrehumbert (eds.), *Papers in laboratory phonology V: Acquisition and the lexicon*, 250–268. Cambridge: Cambridge University Press.

Bybee, Joan. 2002. Word frequency and context of use in the lexical diffusion of phonetically-conditioned sound change. *Language Variation and Change* 14. 261–290.

Bybee, Joan. 2003. Mechanisms of change in grammaticization: The role of frequency. In Brian D. Joseph & Richard D. Janda (eds.), *The handbook of historical linguistics*, 602–623. Malden, MA: Blackwell.

Canepari, Luciano. 1979. *Introduzione alla fonetica*. Turin: Einaudi.

Carrasco, Patricio. 2008. *An acoustic study of voiced stop allophony in Costa Rican Spanish*. Urbana-Champaign, IL: University of Illinois dissertation.

Colantoni, Laura & Irina Marinescu. 2010. The scope of stop weakening in Argentine Spanish. In Marta Ortega-Llebaria (ed.), *Selected proceedings of the 4th conference on laboratory approaches to Spanish phonology*, 100–114. Somerville, MA: Cascadilla Proceedings Project.

Cole, Jennifer, José I. Hualde & Khalil Iskarous. 1999. Effects of prosodic context on /g/ lenition in Spanish. In Osamu Fujimura, Brian D. Joseph & Bohumil Palek (eds.), *Proceedings of the 4th international linguistics and phonetics conference*, 575–589. Prague: The Karolinium Press.

Cravens, Thomas. 2002. *Comparative historical dialectology: Italo-Romance clues to Ibero-Romance sound change*. Amsterdam: John Benjamins.

Dalbera-Stefanaggi, Marie José. 1991. *Unité et diversité des parlers corses*. Alessandria: Edizioni dell'Orso.

Duez, Danielle. 1995. On spontaneous French speech: Aspects of the reduction and contextual assimilation of voiced stops. *Journal of Phonetics* 23(4). 407–427.

Eddington, David. 2009. A gradient analysis of Spanish voiced approximants: New data undermine traditional notions. Paper presented at Phonetics and Phonology in Iberia 2009, Las Palmas de Gran Canaria, June 17–19.

Figge, Udo. 1966. *Die romanische Anlautsonorisation*. Bonn: Romanisches Seminar der Universität Bonn.

Foley, James A. 1977. *Foundations of theoretical phonology*. Cambridge: Cambridge University Press.

Gahl, Susanne. 2008. *Thyme* and *time* are not homophones: The effect of lemma frequency on word durations in spontaneous speech. *Language* 84(3). 474–496.

Goldstein, Louis M. & Carol Fowler. 2003. Articulatory phonology: A phonology for public language use. In Antje S. Meyer & Niels O. Schiller (eds.), *Phonetics and phonology in language comprehension and production: Differences and similarities*, 159–207. Berlin/New York: Mouton de Gruyter.

Guitart, Jorge. 1978. Aspectos del consonantismo habanero: Reexamen descriptivo. *Boletín de la Academia Puertorriqueña de la Lengua Española* 7. 95–114.

Hall, Robert A., Jr. 1964. Initial consonants and syntactic doubling in West Romance. *Language* 40. 551–556.

Harris, James. 1969. *Spanish phonology*. Cambridge, MA: MIT Press.

Honeybone, Patrick. 2001. Lenition inhibition in Liverpool English. *English Language and Linguistics* 5(2). 213–249.

Hualde, José I. 2011. Sound change. In Marc van Oostendorp, Colin J. Ewen, Elizabeth Hume & Keren Rice (eds.), *The Blackwell Companion to Phonology*. London and New York: Blackwell Publishing. Blackwell Reference Online. <http://www.companiontophonology.com/subscriber/tocnode?id=g9781405184236_chunk_g978140518423695>. (Accessed 24 May 2011).

Hualde, José I., Marianna Nadeu & Miquel Simonet. 2010. Lenition and phonemic contrast in two Catalan dialects. In Sonia Colina, Antxon Olarrea & Ana Carvalho (eds.), *Romance linguistics 2009: Selected papers from the 39th linguistic symposium on Romance languages*, 63–79. Amsterdam: John Benjamins.

Hyman, Larry. 1975. *Phonology: Theory and analysis*. New York: Holt, Rinehart & Winston.

Hyman, Larry. 1976. Phonologization. In Alphonse Juilland (ed.), *Linguistic studies offered to Joseph Greenberg*, vol. 2, 407–418. Saratoga, CA: Amma Libri.

Jones, Michael A. 1997. Sardinian. In Martin Maiden & Mair Parry (eds.), *The dialects of Italy*, 376–384. London: Routledge.

Jurafsky, Daniel, Alan Bell, Michelle Gregory & William D. Raymond. 2001. Probabilistic relations between words: Evidence from reduction in lexical production. In Joan Bybee & Paul Hopper (eds.), *Frequency and the emergence of linguistic structure*, 229–254. Amsterdam: John Benjamins.

Kingston, John. 2008. Lenition. In Laura Colantoni & Jeffrey Steele (eds.), *Selected proceedings of the 3rd conference on laboratory approaches to Spanish phonology*, 1–31. Somerville, MA.: Cascadilla Proceedings Project.

Kirchner, Robert. 2001. *An effort-based approach to consonant lenition*. London: Routledge.

Labov, William. 1981. Resolving the Neogrammarian controversy. *Language* 57. 267–308.

Labov, William. 1994. *Principles of linguistic change*. Vol. 1: *Internal factors*. Oxford: Blackwell.

Labov, William. 2006. A sociolinguistic perspective on sociophonetic research. *Journal of Phonetics* 34. 500–515.

Lass, Roger. 1993. How real(ist) are reconstructions?. In Charles Jones (ed.), *Historical linguistics: Problems and perspectives*, 156–189. Harlow, Essex: Longman.

Lavoie, Lisa. 2001. *Consonant strength: Phonological patterns and phonetic manifestations*. New York: Garland.

Lewis, Anthony Murray. 2001. *Weakening of intervocalic /ptk/ in two Spanish dialects: Toward the quantification of lenition processes.* Urbana-Champaign, IL: University of Illinois dissertation.

Lleal, Coloma. 1988. El «Llibre de politigas» i l'evolució de l'antroponímia [The "Book of Policies" and the evolution of anthroponymy]. In Albert Manent and Joan Veny (eds.), *Miscel·lània d'homenatge a Enric Moreu-Rey, Volum 1*, 319–336. Barcelona: Publicacions de l'Abadia de Montserrat.

Loporcaro, Michele. 2009. *Profilo linguistico dei dialetti italiani*. Bari: Laterza.

Machuca Ayuso, María Jesús. 1997. Las obstruyentes no continuas del español: relación entre las categorías fonéticas y fonológicas en habla espontánea. Barcelona: Universitat Autònoma de Barcelona dissertation.

Martínez Celdrán, Eugenio. 2009. Sonorización de las oclusivas sordas en una hablante murciana: Problemas que plantea. *Estudios de Fonética Experimental* 18. 253–271.

Mascaró, Joan. 1984. Continuant spreading in Basque, Catalan and Spanish. In Mark Aronoff & Richard T. Oehrle (eds.), *Language sound structure*, 287–298. Cambridge, MA: MIT Press.

Oftedal, Magne. 1985. *Lenition in Celtic and in Insular Spanish: The second voicing of stops in Gran Canaria*. Oslo: Universitetsforlaget.

Ohala, John. 1974. Experimental historical phonology. In John M. Anderson & Charles Jones (eds.), *Historical linguistics*, vol. 2, 353–389. Amsterdam: North Holland.

Ohala, John. 1983. The origin of sound patterns in vocal tract constraints. In Peter F. MacNeilage (ed.), *The Production of Speech,* 189–216. New York: Springer.

Ohala, John. 1990. The phonetics and phonology of aspects of assimilation. In John Kingston & Mary Beckman (eds.), *Papers in laboratory phonology I: Between the grammar and physics of speech*, 258–275. Cambridge: Cambridge University Press.

Ohala, John. 1992. Comments on chapter 10. In Gerard J. Docherty & D. Robert Ladd (eds.), *Papers in laboratory phonology II: Gesture, segment, prosody*, 286–287. Cambridge: Cambridge University Press.

Ohala, John. 1997. Aerodynamics of Phonology. In *Proceedings of the 4th Seoul international conference on linguistics*, 92–97. Seoul: Linguistic Society of Korea.

Ohala, John. 2003. Phonetics and historical phonology. In Brian D. Joseph & Richard D. Janda (eds.), *The handbook of historical linguistics*, 669–686. Malden, MA: Blackwell.

Ohala, John & Carol J. Riordan. 1979. Passive vocal tract enlargement during voiced stops. In Jared L. Wolf & Dennis H. Klatt, (eds.), *Speech communication papers*, 89–92. New York: Acoustical Society of America.

Ortega-Llebaria, Marta. 2004. Interplay between phonetic and inventory constraints in the degree of spirantization of voiced stops: Comparing intervocalic /b/ and intervocalic /g/ in Spanish and English. In Timothy Face (ed.), *Laboratory approaches to Spanish phonology*, 237–253. Berlin/New York: Mouton de Gruyter.

Parrell, Benjamin. 2010. Articulation from acoustics: Estimating constriction degree from the acoustic signal. *Journal of the Acoustical Society of America* 128(4). 2289.

Pierrehumbert, Janet. 2002. Word-specific phonetics. In Carlos Gussenhoven & Natasha Warner (eds.), *Laboratory phonology VII*, 101–140. Berlin/New York: Mouton de Gruyter.

Recasens, Daniel. 2002. Weakening and strengthening in Romance revisited. *Rivista di Linguistica* 14. 327–373.

Romero, Joaquín, Ben Parrell & Maria Riera. 2007. What distinguishes /ptk/ from /bdg/ in Spanish?. Poster presented at Phonetics and Phonology in Iberia 2007, Braga, Portugal, June 25–26.

Shockey, Linda. 2003. *Sound patterns of spoken English*. Malden, MA: Blackwell.

Simonet, Miquel. 2008. *Language contact in Majorca: An experimental sociophonetic approach*. Urbana-Champaign, IL: University of Illinois dissertation.

Simonet, Miquel. 2010. Rating accented speech on continua: Nativeness in speech production in highly proficient bilinguals. In Marta Ortega-Llebaria (ed.), *Selected proceedings of the 4th conference on laboratory approaches to Spanish phonology*, 37–46. Somerville, MA: Cascadilla Proceedings Project.

Soler, Antonia & Joaquín Romero. 1999. The role of duration in stop lenition in Spanish. In *Proceedings of the International Congress of Phonetic Sciences 99*, San Francisco, 483–486.

Torreblanca, Máximo. 1976. La sonorización de las oclusivas sordas en el habla toledana. *Boletín de la Real Academia Española* 56(207). 117–146.

Torreblanca, Máximo. 1979. Un rasgo fonológico de la lengua española. *Hispanic Review* 47(4). 455–468.

Trujillo, José Ramón. 1980. Sonorización de sordas en Canarias. *Anuario de Letras* 18. 247–254.

Wartburg, Walther von. 1936. Die Ausgliederung der romanischen Sprachräume. *Zeitschrift für Romanische Philologie* 56(1). 1–48.

Wartburg, Walther von. 1950. *Die Ausgliederung der romanischen Sprachräume*. Bern: Francke.

Weinrich, Harald. 1958. *Phonologische Studien zur romanischen Sprachgeschichte*. Münster: Aschendorff.