Gran Canarian Spanish non-continuant voicing: gradiency, sex differences and perception[1]

Karolina Broś and Katarzyna Lipowska

University of Warsaw

Corresponding author:

Karolina Broś, Dzielna 78/5, 01-029 Warszawa, Poland

e-mail address: k.bros@uw.edu.pl

telephone number: 0048503111616

[1] This paper is an extended version of a poster presentation given at OCP 14 in Dusseldorf, February 2017, which provided data on the voicing variable from Gran Canarian speaker productions. We would like to thank the conference participants for all their useful comments and suggestions concerning further developments of the study.

Abstract

This paper examines the process of post-vocalic voicing in the Spanish of Gran Canaria from the point of view of language change. A perception-production study was designed to measure the extent of variation in speaker productions, explore the degree to which production is affected by perception and identify variables that can be considered markers of sound change in progress. To this end, 20 native speakers of the dialect were asked to repeat auditory input data containing voiceless non-continuants with and without voicing. Based on their productions, it was established that input voicing has no effect on output pronunciations but voicing is highly variable, with both phonetic and social factors involved. Most importantly, a clear lenition pattern was identified based on such indicators as consonant duration, intensity ratio, absence of burst and presence of formants, with the velar /k/ as the most affected segment. Furthermore, strong social implications were identified: voicing degrees and rates depend both on the level of education and on the gender of the speaker, which suggests that the interplay of external and internal factors must be investigated more thoroughly to better address the question of phonetic variation and phonologisation of contrasts in the context of language change.

1. Introduction

The process of voiceless non-continuant (/p t k tʃ/) voicing has been described as an incipient sound change taking place in several Romance languages, including Corsican (Gurevich 2004), Sardinian (Loporcaro 2009; Jones 1997), Italian (Dalcher 2008, Hualde & Nadeu 2011) and Spanish.[2] In the latter language, several dialects seem to present varying degrees of intervocalic *fortis* stop voicing, from Peninsular varieties (e.g. Lewis 2001; Martínez Celdrán 2009; Torreblanca 1976; Torreira & Ernestus 2011) to Central America and the Caribbean (Guitart 1978; Quilis 1993). The phenomenon seems to be gaining ground not only in dialects that are traditionally considered non-conservative (e.g. varieties spoken in Andalusia or the Caribbean), but also in other parts of the Spanish-speaking world. It is, however, still not stable or categorical, and depends on a variety of factors. Many studies point to both inter- and intraspeaker variation in the production of /p t k/. In a small study encompassing 4 speakers of Spanish from Barcelona, Machuca (1997) reports *fortis* stop voicing rates ranging from 34.9% to 64.6% in spontaneous speech depending on the person. The degrees of voicing differed, and some

[2] As suggested by a reviewer, it should be noted that in the case of Spanish we are talking about a second round of voicing from the historical perspective (Latin roots with intervocalic voiceless stops underwent voicing centuries ago, e.g. *vita* -> *vida* [biða] 'life'), whereas in the case of Corsican, Sardinian or Central-Southern Italian the original Latin voiceless stops show variable voicing now.

stops were produced as approximants. In a fairly recent study, Hualde et al. (2011) examined spontaneous and scripted productions of 20 native Spanish speakers from Majorca. The analysis revealed that the voicing of /p t k/ in intervocalic position is fairly frequent (35.7% in the spontaneous speech corpus, compared to only 3.6% in read sentences). Hualde et al. also report substantial inter-speaker variation. Interestingly, the voiced outputs of /p t k/ were usually realised as continuants in their study, which makes them very similar to phonological /b d g/ that are approximantised in the same environment. Such a state of affairs raises questions about the phonological merger of contrasts, hence other phonetic variables pointing e.g. to differences in the degree of constriction are worth measuring. Hualde et al.'s analysis demonstrated that there is a difference in consonant duration and constriction degree depending on the voicing of /p t k/ and compared to underlying voiced segments. No phonological merger, however, was confirmed due to the discrepancies between underlyingly voiced and voiceless sounds when compared by place of articulation, although the velar stop showed the greatest level of lenition. Herrera (1997) and Lewis (2001) point to speech style as an important factor governing the differences in the rates of voicing, with formal styles showing the change /p t k/ -> [b d g] only sporadically. Hualde et al. (2011) mention yet another variable – stress. In their study of /p t k/ voicing, there is a clear difference in the frequency of [b d g] depending on the type of syllable the stop belongs to. Finally, the place of articulation is said to play a role in the degree of weakening (e.g. Torreira & Ernestus 2011). It is worth mentioning at this point that in our treatment of post-vocalic voicing we look at the process from the perspective o language change, and more specifically lenition/weakening. The latter phenomenon encompasses all those phonetic and phonological processes that lead to eventual segment elision, hence voicing, spirantisation/approximantisation, debuccalisation and related processes. These usually involve sound shortening, greater aperture (weaker constriction) and greater coarticulation (loss or overlap of individual articulatory gestures, target undershoot) which are consequences or manifestations of greater articulatory ease (effort minimisation), higher speech rate, biomechanical limitations and lower speech precision. Various internal and external factors contribute to sound weakening, some of which are discussed later in this paper.

As for perception, there are not many studies that address this issue in connection with stop voicing and possible merger with /b d g/, although Romero et al. (2007), for instance, argue that native speakers can reliably distinguish between underlyingly voiced and voiceless stops regardless of their surface constriction, voicing and duration. The latter feature has been reported as an important indicator of both voicing and constriction (e.g. Lavoie 2001; Parrell 2011). Martínez Celdrán (1993) states that if the period of silence preceding the release of a voiceless stop is shortened, the consonant will be perceived as voiced. In another study, he shows that speakers are confused when hearing words with voiced stops in isolation but are able to reliably distinguish meanings when confronted with full phrases in a perception test (Martínez Celdrán 2009). This suggests that voicing obscures comprehension and context is needed to get at the meaning of a word with a voiceless stop that underwent voicing. Interestingly, however, speakers of the same dialect (here: Murcia Spanish) were better at recognising words than speakers of a different variety (Barcelona).

Given the abundance of phonetic studies showing variation in the production of voiceless non-continuants, information concerning the way this is processed by listeners and how it affects their future outputs is key to understanding phonetic variability and sound change. The present study aims to address this issue by providing production data correlated with perception. More specifically, we did not aim to test the perception of voiced outputs in itself (as related to the recognition of lexical contrasts). Rather, we wanted to use audition as a variable that potentially affects speaker productions. Our goal was also to see which features govern the differences between underlying and surface sounds, and whether they affect listener behaviour. The dialect taken under scrutiny, i.e. Gran Canarian Spanish, has been described as abounding in various types of consonantal lenition, including high rates of intervocalic voicing (Herrera 1989; Marrero 1986; Trujillo 1980; Oftedal 1985). As reported in the literature, speakers of Canary Islands Spanish freely produce voiced variants of [p t k] in spontaneous speech regardless of age, sex or social status, although Trujillo (1980) points out that the phenomenon is more widespread among the speakers from rural areas. The social reach of voicing was confirmed recently by Broś (2016a) based on fieldwork recordings of natural speech produced by Gran Canarian natives of different ages. The process involves all voiceless non-continuants /p t k tʃ/ both inside words and across word boundaries in strictly post-vocalic position. Some examples are provided below.[3]

(1) Examples of post-vocalic voicing observed both inside words and across word boundaries

a. /p/ de[b]artamento ‘department’ e. /p/ yo [b]ienso ‘I think’

[3] It must be noted that in the Spanish of the Canary Islands, the prepalatal (or palato-alveolar) affricate has been reported to be produced as a palatal affricate [cç] or even stop [c], hence its voiced counterpart would be [ɟʝ] or [ɟ]. Depending on the study, the symbols and names used for the Canarian sound differ, which is why we decided to use IPA symbols for clarity. In our data, as in e.g. Dorta (1997), the affricate is often pronounced differently from the standard palato-alveolar [tʃ] found in Peninsular Spanish. Since pronunciations differ from one speaker to another and the exact place and manner of articulation are outside the scope of this paper, we decided to use the [tʃ] symbol to refer to it and describe it as a prepalatal affricate in accordance with the Spanish-speaking literature. It should be noted, however, that the periods of closure and frication vary across speakers and depending on the degree of voicing. In general, our data show that females tend to produce a standard [tʃ] with a definite frication period and no voicing, whereas males typically produce a tenser variant whose frication period is shorter or even absent, with higher rates of voicing. The latter sound would be best referred to as ‘adherent *ch*’ described by Alvar & Quilis (1966), Dorta (1997) and others.

b. /t/ foné[d]ica ‘phonetics’
c. /k/ má[g]ina ‘machine’
d. /tʃ/ le[dʒ]e ‘milk’
f. /t/ juntos y [d]al ‘together etc.’
g. /k/ de [g]olombia ‘of Colombia’
h. /tʃ/ la [dʒ]ica ‘the girl’

Apart from intervocalic position, Broś (2016a) reports voicing before a liquid consonant (e.g. *la playa* [la.**b**lá.ja] ‘triple’), which seems to follow the trajectory of consonantal changes observed historically in the transition from Latin to Spanish (Lloyd 1987). The phenomenon seems to be very frequent in spontaneous productions, although it does not affect all voiceless non-continuants in an utterance. As it is sensitive to pauses and speech rate, it can be deemed coarticulatory. Furthermore, speech style is believed to be a major factor influencing the rate of voicing. As reported by Herrera (1997), Gran Canarian speakers asked to read lists of words containing intervocalic voiceless non-continuants voice them only rarely. As for other accounts, Trujillo (1980) deems the process an important change in progress, and Oftedal (1985) alludes to the historical shift in the phonological categories of Spanish stops as a parallel of what can be observed today. The reported propensity for voicing and the simultaneous variation in production point to the phonetic nature of the process. Nevertheless, interaction with phonological phenomena puts such an interpretation into question. As demonstrated by Broś (2016b), voicing is blocked by the deletion of a preceding sound even though it should occur given the phonetic context. For instance, the phrase *pensar tonterías* ‘to think silly things’ is realised [pensá**t**ontería], i.e. with a voiceless [t] although the final *r* of the word *pensar* is deleted. The same speaker regularly produces voicing in underlyingly post-vocalic contexts. This makes Gran Canarian voicing phonological or at least allows the phonetic component of the grammar to interpret information provided by the phonological structure.

2. Experiment

Given the above facts, we decided to check which parameters are important in the production of voicing in the Gran Canarian variety of Spanish. We wanted to see whether the rates of voicing in experimental conditions would be similar to the ones reported for spontaneous speech, and whether they depend on auditory input. The latter question is important from the point of view of perception and interpretation of speech by listeners. In other words, we were interested in the speakers’ response to variability. It is a generally accepted fact that in speech processing, production is mediated by the perception and interpretation of the auditory signal, as well as other factors. Because the phonetic output of a given individual may vary depending on a series of variables, such as speech rate, style, context or interlocutor, this may affect how listeners perceive and (re)produce speech during communication. Moreover, as argued by Ohala (1981, 1990), the intention of the interlocutor and the way it is discerned by the listener in communication is one of the main factors influencing sound change. Speakers base their interpretations on actual pronunciations, hence they may interpret unintended articulator movements resulting from a faster speech rate, overlap and undershoot as intended targets. In this way, sporadic or accidental phonetic changes generalise, and sound change can be observed in a given speech community. To see how differences in production are processed and reproduced by speakers, a perception-production study was conducted among native speakers of Gran Canarian Spanish. Audio stimuli in two versions: voiced and voiceless were designed to mimic interaction in communicative situations. Such an experiment design was chosen to elicit productions based on the semantic meaning and the mental lexicon rather than orthography. Avoiding read speech favours more natural, everyday articulation, and the use of voiced stimuli as inputs should promote voicing rather than standardisation.[4] We expected that experiment participants would voice the target sounds, and that they would be quite consistent in their productions. We did not expect much inter-speaker variability (most speakers were in their twenties and from similar backgrounds), however, we wanted to see whether there are differences in production depending on the place of articulation.

3. Methods

Participants

20 speakers of Gran Canarian Spanish (11 males and 9 females) aged 17-37 (mean 25.5, *sd* 4.3) participated in the experiment. They were recruited in the region of Gáldar, Las Palmas de Gran Canaria. 10 of them had a full university degree, 4 were university students at the time of the recording, and 6 had secondary school education. Table 1 presents participant details.

Stimuli

The stimuli used in the experiment consisted of 49 phrases containing contexts for post-vocalic voicing across a word boundary. Each sentence was structured in the same way: *He comprado cinco* 'I have bought five', followed by a noun phrase, e.g. *panes de millo* 'corn breads'. The NP always consisted of a noun denoting a container or an object made of other objects/ingredients (the target word), followed

[4] An important reason for avoiding written language and using variable productions in the input is the fact that consonant weakening is stigmatised in the speech of the Canary Islands. This is subject to a heated debate, and various authors point to the rates of 'correction', teaching Canarians Peninsular Spanish pronunciations in schools and diffusing them as a model in the media (Moreno 2000; Morera 1990).

by a prepositional phrase introduced by *de* ‘of’. The left-hand environment was always the vowel [o], whereas the target segment was [p], [t], [k] or [tʃ], where post-vocalic voicing is expected. There were 10 different noun phrases per sound plus 3 different noun phrases per [pr], [tr] and [kr] sound combinations. The latter set was used to control for right-hand environments other than vowels given that the analysed process is post-vocalic rather than strictly intervocalic. Stop plus liquid clusters are frequent in Spanish. The combination [tʃr], however, does not exist, hence it was not taken into account in the study. As for the choice of words for the stimuli, they were all consulted with a native speaker of the dialect. It is difficult to reliably establish their frequencies given that no Canary Islands Spanish corpus for oral speech exists. Most words are frequently used in general Spanish (Spanish Corpus CREA and RAE dictionary, www.rae.es). Some were local words generally known by the population and listed in the dictionary of Canarian terms (http://www.academiacanarialengua.org), e.g. *traba*, general Spanish *pinza* ‘clothespin’, *chincheta* ‘pushpin’ or *trucha* – a Canarian sweet typically eaten during Christmas. The full list of stimuli is presented in the Appendix. Sentence length was limited given the nature of the task. We wanted to make sure that each participant would be able to repeat the stimuli based on auditory perception only.

Given that the experiment was based on audio input data, the stimuli had to be pre-recorded. A trained male native speaker from Gáldar produced two sets of phrases: with and without voicing.[5] The recordings were made using Zoom H4N digital recorder and a Shure SM10a headworn microphone. The same equipment was used during the experiment. The input phrases were subsequently cut and analysed in Praat (Boersma & Weenink 2015) to ensure voicing where needed and control for pauses and overall recording quality. Fillers constructed in the same way as test sentences, with vowels, fricatives and voiced sounds instead of the target sounds were added. All audio files were then put together and two randomised sets were created, one per 10 participants.

Procedure

[5] The choice of the speaker was based on the fact that he was a definite frequent voicer. The gender of the speaker was not of our concern given that according to previous studies, voicing is quite consistent in all speakers, both males and females of different ages. Since the study was not primarily focused on accommodation or speaker discrimination, both genders were listening to one speaker. As noted by a reviewer, however, this might have influenced the results given that participants may have voiced more readily if they were of the same gender as the recorded speaker. We see this as a limitation of the study. Nevertheless, according to our results, input voicing did not influence output voicing in general nor when the two genders are compared (neither males nor females accommodate to the speaker from the recording). The only significant effect was observed in the case of the prepalatal (see the Results section). The question of covert prestige or lack thereof and the corresponding behaviour of the participants should not be ignored, however. Unfortunately, although two of the females were the heaviest voicers among the participants of the study and hence seemed to have an idiolectal tendency to voice stops everywhere, we cannot rule out the possibility that at least some of the other females reacted to the input in a negative way and adjusted their pronunciations **because** the speaker was male (e.g. to differentiate themselves from him).

The participants were asked to wear the microphone and headphones connected to a laptop computer and sit in front of a desk. Sound files with the stimuli were prepared to be played by the experimenter. The volume level was the same for all the participants. They confirmed that they could hear the recordings properly. After sitting down, they were instructed that upon hearing each sentence played by the experimenter they were to repeat it as naturally as possible. If they made a mistake during the repetition phase, they were asked to repeat the whole sentence. Subsequently, the experimenter would start the procedure, playing each stimulus in a predetermined order from a separate audio file. It was assumed that each sentence could be heard only once. Although some speakers had to repeat some of the sentences twice due to slips of the tongue, it was not necessary to repeat the recording in any of the cases.

Measurements

To determine whether voicing is systematic and whether it follows the pattern produced in the stimuli, the voicing bar, glottal pulses and the voice report generated by Praat (Boersma and Weenink, 2015) were examined for each of the target sounds manually, in the course of visual inspection of the spectrograms. Given the voicing trail of the preceding vowel and other phonetic considerations, a rigorous classification of the sounds was made. It was decided that a given stop is voiced if pulses are present throughout the sound. It was annotated as partially voiced if more than 50% of the sound duration showed voicing on the spectrogram. Otherwise, the sound was deemed not voiced. Partial and full voicing were measured and then analysed both separately and when pooled together for comparison. Following the general analysis of output voicing and its relation to the input voicing of the target sounds, further measurements were made to assess the degree of weakening.

The degree of aperture was assessed indirectly via visual inspection of the spectrograms. It was assumed that weakened consonants present less constriction as they tend to be more vowel-like in terms of muscle tenseness and proximity of the articulators (Vennemann 1988, Zec 1995). One of the acoustic measurements of such changes in manner is the presence of **formants**, hence variable approximantisation of input stops. In our data, we observed variation in this respect, which was annotated and submitted for statistical analysis per sound and in correlation with other variables. More specifically, when some but not all formants were present on the spectrogram, the sound was annotated as weakly approximantised (marked with the digit 1, see Fig.1). When a clear formant pattern was seen and the sound looked more like a sonorant, with only very slight formant transitions with respect to the flanking vowels, it was annotated as strongly approximantised (marked with 2, see Fig. 2).

Intensity ratio and **intensity difference** were calculated as two other indicators of the degree of constriction of a given consonant. For this purpose, two measurements were taken: the minimum intensity of the target sound and the maximum intensity of the following vowel (in decibels). The first measurement divided by the second gives the intensity ratio whose value is expected to be closer to 1 with a higher degree of lenition (Carrasco et al. 2012). The lower the ratio (i.e. the greater the difference between the two intensity values), the more consonantal a given sound. Voiced non-continuants should have a higher intensity ratio when compared to the unvoiced ones. Consonants showing stronger lenition markers, such as formants, should also have a higher intensity ratio. This measure, alongside similar variables, has been used in several studies on consonant weakening (e.g. Ortega-Llebaria, 2004; Colantoni and Marinescu, 2010; Hualde et al., 2010). Carrasco et al. (2012) have shown that there are significant differences in the intensity ratio between voiceless stops and stops voiced by lenition in Spanish. Some studies (e.g. Hualde & Nadeu, 2011) used another intensity-related index, namely intensity difference measured by subtracting one of the abovementioned values from the other (consonant from vowel). We decided to use it in our study for comparative purposes as several papers have shown that using more than one intensity measure helps to provide more comprehensive information on the degree of lenition (see e.g. Hualde et al., 2011; Hualde & Nadeu, 2011). In this case, the more constricted the consonant the greater the intensity difference, hence we expect lower values of this index in the case of lenition.[6] In /pr/, /tr/ and /kr/ clusters, intensity measurements were made on the vowel following the /r/. This follows the methodology used by Hualde & Nadeu (2011) who measure relative intensity with the omission of a glide or liquid following the stop in VCGV / VCLV sequences in Rome Italian.

Burst absence rate was deemed important in lenition processes by e.g. Dalcher (2008). Since only maximally constricted consonants produce bursts, complete closure must be maintained long enough (at least 20-30 ms) to ensure sufficient air pressure build-up and then abrupt release (Shadle

[6] It is worth mentioning that Parrell (2010) compared the two indices used in this study together with one more variable (maximum velocity), concluding that intensity ratio is the most reliable index as it shows the strongest correlation with articulatory data. Although it is unclear how the intensity ratio should be calculated based on Parrell's presentation, the methodology is stated explicitly by other authors, e.g. Carrasco et al. (2012: 156) whose statistical analysis is based on "the intensity ratio resulting from dividing the two values [in decibels] (min/max) at the two points".

1997). In our data, we observed that bursts are not necessarily produced and may or may not correlate with the voicing of a given stop, hence the variable was included in the statistical analysis.

Finally, **constriction duration** was measured as another lenition indicator. In accordance with the literature, constriction is expected to decrease proportionately to the degree of weakening. According to Dalcher (2008), weaker variants are progressively shorter and the percentage of voicing depends on constriction duration. At the same time, however, she has shown that **relative consonant duration** appears to be a more reliable indicator of weakening than relative constriction duration in Florentine Italian. The two variables were taken into account in the statistical analysis. The former is measured as a ratio of total consonant duration (constriction + release/positive VOT) to total VCV sequence duration, while the latter is a ratio of constriction duration to total VCV sequence. In this way, the values can be compared across speakers. VCRV sequences had to be excluded from the data for this measurement given that no reliable comparison can be made as to any of the ratios (both depend on the length of the sequence in ms). Also, some items had to be excluded from length and/or constriction measurements when they were produced as strong approximants. In such cases, the presence of formants made it impossible to reliably establish the boundary between the consonant and the flanking vowels.

In all measurements, items with pauses/hesitations were excluded from statistical analysis to provide the most reliable results possible. The total number of analysed sounds was 1,911, and in the case of analyses excluding the affricate (burst, formants, constriction) – 1,520 (1,171 excl. clusters). A general summary of the results per sound (raw data) is presented in Table 2.

Statistical methods

The analyses presented below were all conducted in R 3.4.2 (R Core Team, 2017) with the package lmer4 (Bates, Maechler, Bolker, & Walker, 2018). Linear mixed effects regression models were estimated using the function lmer(); for mixed effects binary logistic regression models, the glmer() function was employed with binomial family and the logit link function. Plots and estimated means were generated using the Effect() function from the effects package (Fox, 2003). In each model there were random intercepts for individual speakers. Full random structure was not employed due to problems with model convergence within 10,000 iterations. Dependent variables and fixed effects are described separately for each model.

4. Results

The study revealed that voicing is not as consistent as assumed prior to running the experiment. The average voicing rate, including full and partial voicing, was only 44.9%, although significant rates of voicing were observed outside the target word across speakers. What is more, the process was not categorical. In accordance with our methodology, full voicing was produced in 29.5% of the cases, and partial voicing – 15.4%. Spectrograms presented in Figures 3 and 4 show partial and complete voicing, respectively. It is worth noting, however, that there was substantial inter-speaker variation in our data. Four speakers voiced non-continuants in more than 75% of the cases. Another four had rates of voicing lower than 5%, including one who did not voice any of the target sounds. Seven people were in the mid-range (25-75%). Also, there were substantial differences between male and female productions. The collected data suggest that females voiced less often (29.3% compared to 59.0% in males).

A mixed effects binary logistic regression was performed with absence/presence of voicing as the dependent variable, and gender, education (university level or high school), input (voiced/unvoiced) and sound (/tʃ/, /k/, /p/, /t/) as independent variables. The effects of sound ($F = 8.0$, $df = 3$, $p < 0.0001$)[7], gender ($F = 4.9$, $df = 1$, $p < 0.05$), sound*gender ($F = 6.0$, $df = 3$, $p < 0.001$) and sound*education ($F = 3.7$, $df = 3$, $p < 0.0001$) were significant (see Fig. 5). The estimated voicing probability was highest for /p/ (52.7%), followed by /k/ (44.7%), /t/ (36.0%) and /tʃ/ (27.3%). This stands in contrast with findings concerning lenition tendencies in Romance (Recasens 2002) and voicing in other Spanish dialects. Hualde et al. (2011), for instance, report /k/ as the most frequently voiced sound in intervocalic position. Interestingly, according to our model, the differences in voicing between /p/ and /k/ were only significant in the case of university educated women (see Table 3 for details). Furthermore, when the speaker was in high school, the voicing rate for /tʃ/ equalled 55.9% (on a par with the voicing rate for /p/, which was 57.1%), but for university-educated speakers this rate equalled 34.3% (the least of all examined sounds, see Table 3). Also, female speakers tended to particularly ‘avoid’ voicing /tʃ/ (raw data show a 21.0% voicing rate compared to 56.9% in males and the difference was statistically significant). In order to further test the sociolinguistic hypothesis that different factors influence voicing in males and females, separate models for both genders were built. We found a statistically significant interaction of sound and education in the model for females ($F = 6.3$, $p < 0.0001$), but not in the model for males ($F = 1.6$, $p = 0.164$). In university-level females, the values for /t/ and /k/ are below 20%, while /tʃ/ voicing is not attested.

[7] The *p* for F values is given on the basis of a log likelihood test.

A slightly different binary logistic mixed model was employed to check the voicing in *r* clusters. Cluster presence ($F = 10.4$, $p < 0.01$) and sound ($F = 7.8$, $p < 0.0001$) resulted significant. Additionally, when specific sounds were being compared on the basis of *z* values, gender was significant at $p < 0.05$, with females being less likely to voice sounds. Thus, the general conclusion is that clusters reduce the probability of voicing.

As for the influence of the input voicing on participant productions, no significant effect was found for all speakers taken together nor for males/females separately, which means that output voicing was not affected by what speakers heard in the recording. Voicing was equally likely after hearing a voiced and a voiceless input (the distributions of voiced and voiceless sounds were around 50% each).

Other variables

The overall **formant presence rate** was 28% (44% in males and 19% in females). The sound which presented formants most often is /k/ (46% of all outputs and 81% of voiced outputs, compared to 26% rates for both /p/ and /t/). In order to test whether formants in /k/ occur significantly more often than in /p/ and /t/, we built a mixed effects binary logistic regression model in R. There were significant effects of sound ($F = 19.9$, $df = 2$, $p < 0.0001$), voicing ($F = 113.2$, $df = 1$, $p < 0.0001$) and gender ($F = 4.5$, $df = 1$, $p < 0.05$). A comparison between sounds showed that there is a significant difference in formant occurrence in /k/ compared to /p/ and /t/. It can be therefore said that /k/ is the least constricted in production based on this indicator.

The mean **intensity ratio** was 0.66 (0.69 in males, 0.64 in females). Voiced productions had a mean of 0.73, and voiceless – 0.60. Those differences were tested using a linear mixed effects regression model. The fixed effects of sound, voicing and their interaction all reached statistical significance ($F = 24.1$ $df = 3$, $p < 0.0001$, $F =356.3$, $df = 1$, $p < 0.0001$, and $F = 27.9$, $df = 3$, $p < 0.0001$, respectively). Not only is intensity ratio higher in the case of voicing, but the effect voicing has on the intensity ratio differs depending on the sound. For instance, the differences between voiced and voiceless realisations are much greater for /k/ and /p/ than for /tʃ/.. The differences in intensity ratio depending on voicing per sound are presented in the form of a boxplot graph in Figure 6. These results are in line with the expected lenition pattern: the more lenited the stop, the less constricted or tense it is, hence the intensity ratio increases. Furthermore, there is a correlation between intensity and the presence of formants. As demonstrated in Figure 7, the intensity ratio rises gradually in proportion to formant presence (higher values in consonants presenting some formants, higher still when formants dominate the articulation of the sound throughout its duration).

The results for mean **intensity difference** are analogical to those obtained for intensity ratio (mean value 17.02, significant effects of sound, voicing and sound*voicing, all with a $p < 0.0001$). The only difference is that the relation between this variable and other lenition indicators goes in the opposite direction: the weaker the constriction, the smaller the intensity difference (see Fig. 7). Thus, the role of intensity as a weakening marker was confirmed.

The **burst absence rate** was 36% across speakers, with a marked difference between the sexes (45% in males, and 25% in females). There was also a substantial difference between voiceless (20.6%) and voiced or partially voiced (52.7%) productions. The sound that was most often produced without a burst was /k/ (58%), followed by /p/ (32%) and /t/ (18%). Again, mixed effects binary logistic regression model was employed. Statistical significance was reached for sound ($F = 36.5$ df = 2, $p < 0.0001$), voicing ($F = 59.8$, df = 1, $p < 0.0001$), gender ($F = 3.8$, df = 1, $p = 0.051$), and sound*voicing ($F = 21.7$, df = 2, $p < 0.0001$). Apart from confirming the expected difference between sounds, burst was more likely in females (z value = 2.044, $p < 0.05$), and when there was no voicing (see Fig. 8).

As for the **relative constriction duration**, the mean for voiced segments was 0.31, compared to 0.33 in voiceless consonants, with no gender difference. We found a significant effect of sound ($F = 36.8$, df = 2, $p < 0.0001$), burst ($F = 153.2$, df = 1, $p < 0.0001$), intensity ratio ($F = 175.9$, df = 1, $p < 0.0001$) and of the following interactions: gender*sound ($F = 5.3$, df = 1, $p < 0.05$), burst*voicing ($F = 31.7$, df = 1, $p < 0.0001$) and burst*voicing*formant ($F = 4.5$, df = 1, $p < 0.05$). According to our results, constriction duration was greatest when there was neither burst nor voicing; it then decreased when there was voicing, even more so if both voicing and burst were present. The shortest constriction duration was predicted in the case of presence of burst. This somewhat surprising pattern held except for /k/ in female speakers. For this reason, separate models were run for each sound to check for any other possible discrepancies. Again, the results were contrary to our expectations. For instance, the burst*voicing interaction in /k/ looks as follows: in the absence of burst, constriction is greater without voicing, but the presence of burst *reverses* the effect of voicing, which instead of reducing constriction makes it longer. We attribute this effect to the fact that in the case of a stop produced with a burst, the constriction duration, measured from the offset of the previous vowel to the release burst, may be shorter than the constriction duration of a consonant without a burst, which is calculated from the offset of V1 to the onset of V2.[8] This variable is therefore not as reliable as total consonant duration in analysing data containing both released and unreleased stops. Similar conclusions were drawn by Dalcher (2008).

Thus, given the burst absence rate, we deem **relative consonant duration** more informative than relative constriction duration. Based on this variable, a clear lenition pathway from voiceless, through partially voiced to fully voiced stops was identified. As can be observed in Fig. 9, the duration of the analysed sounds gradually decreases with voicing, regardless of the place of articulation. The average total duration for all consonants taken together was 64 ms in the case of voiced outputs (72 ms for partially voiced and 60 ms for fully voiced), and 87 ms in the case of unvoiced productions. The difference in the duration of all voiced consonants with respect to unvoiced tokens is 26.4%, but a clear leader can be discerned: whereas all individual sounds show a 23.7-23.8% decrease in duration whenever produced with voicing, /k/ duration drops by 30.2% (see Table 4). Thus, despite the fact that it is not voiced the most often, /k/ is definitely shortened the most. The duration results can be treated as an indicator of lenition, similarly to other studies raising the question of how this variable correlates with sound weakening. Hualde & Nadeu (2011), for instance, find a clear difference in the durations of voiced and voiceless allophones of /p t k/ in Rome Italian. Their regression analyses point to a significant difference between the two sets of allophones with respect to one another, and with respect to underlying /b d g/, which makes duration an important correlate of lenition in stops. The differences in duration reported in this paper are similar to the results for /p t k/ and /b d g/ estimated by Parrell (2011). Other studies comparing the two classes of sounds in Spanish, however, report greater discrepancies (around 40-50 ms, with the shortest contrast in velars: ~ 18 ms, Lavoie 2001). This may be due to the fact that underlyingly voiced stops typically realised as approximants were taken into account in that study, whereas we consider derived voiced stops only. There is reason to believe that durational differences between the latter two types of consonants would be observed in the dialect studied here in line with the general assumption that underlying differences take the form of different articulatory targets.

Additional points

As reported by previous studies on lenition in Spanish, **stress** may also play a role. According to Hualde et al. (2011), the voicing of /p t k/ in spontaneous speech in Iberian Spanish increases from 23.5% to 39.4% in unstressed syllables. Similarly, in their investigation of Costa Rican Spanish lenition, Carrasco

[8] It should be noted that if no burst was visible but there was some energy or friction after the stop closure, this post-closure period was included in the constriction/consonant duration rather than considered to be a part of the onset of the following vowel.

et al. (2012) found unstressed /b d g/ to be more lenited than stressed ones. In our study, 21 out of 49 target sounds were placed in an unstressed syllable (trisyllabic words). The rest occupy onsets of stressed syllables (in disyllabic words with penultimate stress). This makes it possible to compare the rates of voicing based on the stress variable. The analysis of the data reveals that there is an overall difference in the rates of voicing in the expected direction: there is more voicing in unstressed syllables (53% vs. 42% in stressed syllables). The results as per the degree of voicing are presented in Figure 10. A mixed effects binary logistic regression model was built with absence/presence of voicing as the dependent variable. Effects of stress ($F = 37.6$, $df = 1$, $p < 0.0001$) and sound ($F = 7.3$, $df = 1$, $p < 0.0001$) were significant. In the next step, we built a model for each sound separately to check which variables influence their respective voicing patterns (see summary Table 5). In the model for /p/, only stress influenced the drop in the probability of voicing. In the models for /k/ and /t/, as expected, the presence of burst but absence of formants result in a smaller probability of voicing. Also, males were more likely to voice /k/ than women. In the model for /t/, we additionally found a significant effect of reduced probability of voicing when the syllable was stressed. /tʃ/ was more likely to be voiced in the absence of stress, when the speaker was male, in high school and had heard a voiced input.

5. Discussion

In our treatment of postvocalic voicing reported here, we are guided by the assumption that it is an instance of lenition, observable in real and apparent time and hence governed by the principles of language change. We are of the opinion that purely phonetic explanations are insufficient to account for variation and its repercussions for language users. Consequently, as a general principle, we embrace the Labovian (1980, 2001, 2006) perspective, or the so-called ‘variationist’ (Guy 2003) approach and believe that sound change is not possible without the community of speakers and speaker interrelations. Following Labov, we assume that language change does not consist in ‘a change in individual habits, but rather the diffusion of new individual forms into the wider community, and [their] adoption [...] as binding conventions’ (1994:47 fn4), which is intimately related to the extraction of ‘constancy’ from ‘variation’ in everyday communication signalled in the theme of this Special Issue. The results reported above support this line of reasoning.

In our study, we looked at the production of native sounds as linked to perception, our question being whether what speakers hear has any influence on their subsequent pronunciations. We also wanted to know how much variation there would be in the data and which linguistic and extralinguistic factors contribute to it. Consequently, the theoretical model we adopt is similar to Hume & Johnson's (2001) proposal, according to which several types of variables affect language production and change, and, subsequently, the phonology of any given language variety. More specifically, the model assumes that both perception and production are in a bidirectional relationship with the phonological representation of a language. Moreover, other factors external to the phonology itself also have a say in how phonological categories are shaped and modified. One of those factors is generalisation (simplification of patterns) and the other – conformity, which governs the ways in which social norms and expectations modulate sound change. In the study of voicing in Gran Canarian, we found evidence on how speaker productions are mediated by social factors and norms, and to some extent by perception, apart from the phonology itself. Such an approach gives us insight into the scale and cause of variation observed in this synchronic lenition process. With this in mind, we discuss major findings from the point of view of sociolinguistics, phonetics and phonology in the rest of this section.

First of all, the results of the experiment suggest that variation in phonetic productions depends both on phonetic variables and on several sociolinguistic factors. Although post-vocalic voicing is a widespread process in Gran Canaria, it is far from being uniform. We see differences in the degrees of voicing and variable behaviour across speakers. The fact that women voice significantly less than men and are more reluctant to voice some sounds (especially *tʃ*) as opposed to others, combined with the education factor, leads us to the conclusion that the process is a non-prestigious feature that tends to be avoided by females, who are or aspire to be of higher social status. This is in line with sociolinguistic studies on gender and prestige (e.g. Eckert 1989, Labov 2001, Trudgill 1972). By contrast, men tend to be more consistent in voicing and their productions differ less in terms of lenition from one sound to another. They voice significantly more across contexts and show higher rates of other language change markers: burst absence rate and formants. Additionally, they seem to be at least to some extent sensitive to the communicative situation, i.e. react more readily to what they hear from the interlocutor and adjust their pronunciations. Raw data show slight effects of input voicing in the case of males, with one strongly significant effect: the voicing of the low prestige prepalatal.[9] Thus, the data gathered in the course of

[9] We deem the prepalatal to be of low prestige given the big difference in voicing rates between males and females for this sound, as well as between the different levels of education. All females presented 0-10% of voicing for this sound except one who voiced all instances of the palatal and another one who voiced it 65% of the time; both have secondary school education only. Additionally, this sound is notorious (speakers are typically aware of 'the special *tʃ*' from Gran Canaria) and women tend to produce it more neutrally (as a more prepalatal variant, with equal constriction and frication phases) as opposed to males whose productions are more tense, retracted and shorter (more stop-like).

the study partially support the gender paradox hypothesis and the assumptions concerning the social grounding of phonetic change. According to Labov (1990), females respond more readily to the speech principles of the upper classes and tend to resist low-prestige sound changes as opposed to men, despite being leaders in changes from below. The female participants of the study were consistently producing /s/ weakening to [h] in their productions (just like males) but avoiding voicing. The former process is generally accepted in the Canary Islands and can be considered a stable process in the Labovian sense, whereas the latter is a change in progress. At the same time, however, the data suggest a slight deviation from further implications of the gender paradox. Women have been reported not to resist, and even lead incipient changes that lie below the level of conscious attention. Sexual differentiation takes place as the change progresses and social awareness starts to play a role (males being less attentive to such issues, Labov 1990). In the case of voicing, speakers seem not to be aware of it. Asked about it, they seem disoriented (our fieldwork experience). Nevertheless, the change is not completely new, as high rates of voicing were already reported in the 1980s, and speakers typically know they have a 'special' /tʃ/ pronunciation, hence some awareness must have developed over the years, possibly affecting female choices (if at the subconscious level only). The fact that the prepalatal is voiced almost exclusively by males may be an indicator of female withdrawal in the face of the change gaining ground. Furthermore, note that gender-based conformity is enhanced by the education factor, which increases variation and points to the perceived prestige of a given pronunciation pattern.

Another explanation for the observed gender differences can be sought in the biomechanics of speech. As reported by Nadeu & Hualde (2015), women present lower degrees of intervocalic voicing of the /p t k/ series in Majorcan Spanish and Basque compared to men. They also showed a correlation between voicing and speech rate in experimental conditions. This may be due to anatomical differences. Since male larynges are larger than those of females, it is more difficult for men to reach the voicing offset position and therefore inhibit voicing in intervocalic position. Such a conclusion was drawn by Lucero & Koenig (2005). According to Nadeu & Hualde (2015: 354), this, combined with the faster speaking rate in males, leads to higher rates of voicing driven by biomechanical factors which could be reinterpreted as 'intended markers of male speech', following Ohala (1981). Thus, spontaneous voiced productions made by men might later undergo (subconscious) social evaluation and lead to further discrepancies between males and females until the incipient change stabilises and spreads to the whole of the speech community. Although further evidence is needed to confirm this hypothesis, it is compatible with the results reported in the present study.

From the phonetic perspective, it is worth noting that despite inter- and intra-speaker variation there are no clearly interpretable differences in voicing depending on the place of articulation. One interesting result should be emphasised, however: contrary to the expectations, /p/ was voiced most often, although this effect is due to gender differences (it was only significant in the case of females). Nevertheless, other variables suggest that /k/ undergoes more advanced lenition (as a leader in burst absence rates, changes in consonant duration and formant presence). This may be due to anatomical and aerodynamic constraints, however, rather than special propensity of velars to lenite more than other obstruents. Note that in line with the aerodynamic voicing constraint (AVC), both shorter closure duration and lax vocal tract walls facilitate voicing. Consonant length modulates the amount of voicing produced in the vocal cords (Ohala 1983). For optimal voicing, the pressure differential (ΔP_{glot}) needs to be maximised, which means that oral pressure (P_{oral}) has to be as low as possible. Shorter consonant duration facilitates this process. The same can be done by passive or active vocal tract expansion, which is easier in the case of a labial (/p/). The aerodynamic approach also explains why /k/ is the most likely to be approximantised: non-anterior places of articulation make it more difficult to maintain voicing due to the amount of space for air pressure build-up in the oral cavity. For this reason, /k/ may resist voicing and at the same time present the highest rate of formants and lack of burst. Furthermore, as Ohala and others argue, the shorter the stop, the more probable it is that it will be produced with an incomplete closure. Our data confirm this: the average duration of the velar produced with formants throughout was 50 ms, and many of the target sounds were shorter than 30 ms, which is more or less the time necessary to produce full closure and then burst.

Thus, in terms of internal factors influencing the production of voiceless stops in the dialect, we can point to slight differences depending on the place of articulation, with a strong indication of /k/ as the one that shows more lenition. Other than that, we observe correlations between those variables which are considered markers of lenition: the weaker the articulation of a sound, the more probable the lack of burst and presence of formants (hence weaker constriction), and the shorter the sound and its closure duration. Also, the weaker the sound, be it only voiced or also approximantised, the higher the intensity ratio (and the smaller the intensity difference). These results are valid for all the tested consonants. Thus, our results support the methodology of measuring the degree of weakening proposed by Lewis (2001), who enumerates five reliable acoustic parameters: closure duration, VOT, voicing, intensity and burst. In our study, four of these parameters clearly show the extent of lenition and its differing degrees across all outputs regardless of the place of articulation (the tendencies are the same in all consonants). Differences depending on the sound, however, do occur when correlated with both social and phonetic factors. For instance, /tʃ/ is avoided both by females and by speakers presenting higher education in general. It also shows greater drops in duration depending on the voicing. The probability of voicing in the case of /t/ is the lowest and drops significantly in comparison to other sounds when the syllable is stressed, which is somewhat surprising given that its voiced counterpart shows the highest rate of deletion in intervocalic position in Spanish. The /t/ was also shorter in men when voiced than in women. The labial /p/, on the other hand, approaches the results of /t/ in terms of formants, but is closer to /k/ in terms of intensity ratio changes dependent on the voicing. These results taken together, however, do not show any clear pattern except for the convergence of various factors on /k/ mentioned above, and the results concerning the prepalatal which may be attributed to social conditioning. Besides the discrepancies between the places of articulation, phonetic context should be mentioned: it appears that voicing is less likely before liquids, which can be treated as a secondary development or extension of a principally intervocalic process. Finally, stress was confirmed as a factor influencing weakening, hence the role of phonology in language change.

What is especially interesting from the theoretical point of view is that, as signalled in the introduction, there are reasons to treat post-vocalic voicing as a part of phonology or a process operating at the phonetics-phonology interface despite the reported variation: a) it produces alternations, and b) it interacts with other processes: spirantisation of /b d g/ and deletion of word-final coda consonants. It is therefore worth thinking about how to accommodate this in the phonological component. The observation that voicing is quite common outside the target word in the study suggests that variation can be due to yet another variable: prosodic factors. Our acoustic data show that fast speech rate and lack of pauses do not necessarily imply voicing, whereas differences in NP phrasing and pitch do affect the production of non-continuants. More specifically, it should be mentioned that the carrier phrases used in the experiment included a complex quantifier phrase (QP) starting with the numeral *cinco* ‘five’ and followed by the target word and a prepositional phrase. From the point of view of Spanish prosody, such a structure is appropriate as an experimental condition given that nouns are typically phrased together with the preceding numerals (Mercedes Cabrera, p.c., cf. Cabrera & Vizcaíno 2010; Prieto

2007). Nevertheless, the QP is quite long, and a stronger relation ensues between the constituents of the NP beginning with the target word than between the numeral and the target word. Hence, it is possible for speakers to make an intonational break between the numeral and the following NP without marking it with a pause e.g. in a reading task. This could take the form of a continuation rise in the pitch contour. An intonational break is also possible when repeating sentences after the speaker as the participants had to 'make sure' they reproduce or remember the word from the audio stimulus correctly. In terms of prosodic boundaries, two interpretations of the stimuli are possible: (*He comprado cinco*)$_{\mathrm{PPh}}$ (*panes de millo*)$_{\mathrm{PPh}}$ and (*He comprado*)$_{\mathrm{PPh}}$ (*cinco panes de millo*)$_{\mathrm{PPh}}$.[10] Our acoustic data seem to lend support to this prediction: the preliminary analysis of some phrase doublets produced by the same speaker with and without voicing shows slight differences in pitch (rise continuation vs. break). This might suggest different phrasing which can either favour or block voicing. Such an interpretation of the data can be explained by the theory of fine-grained phonetic modulation of speech at prosodic junctures (Cho 2016), which assumes phonetic strengthening at domain boundaries (Fougeron & Keating 1997). If the numeral is phrased separately, voicing will not be promoted, whereas if it is phrased together with the following NP, voicing may occur freely. In this way, we might also be able to explain the overall rate of voicing, which was much lower than expected.

Finally, we must mention the limitations of the study. First, as mentioned in fn. 6, the input data were produced by a male speaker, which may have influenced both male and female productions. Although the statistical analysis did not show any correlation between the voicing of the input and output productions, it is possible that at least some of the speakers spoke with a voicing frequency that does not reflect their everyday speech. The education factor is another possible limitation. The total number of speakers with high school education was 6 and only 2 out of 10 males were in this group, which means that the results showing male-female differences by education level should be treated with caution.

6. Conclusion

The data presented in this study disprove previous reports on intervocalic voicing in Gran Canaria, showing lower than expected rates of sonorisation, as well as substantial gradiency effects. Based on

---

[10] The *PPh* abbreviation is used to refer to a minor phrase (phonological phrase), whose importance for Spanish has been argued for e.g. by Prieto (2007).

the results, we conclude that variation, which is a key feature of language change in progress exemplified here by Canary Islands Spanish, cannot be analysed strictly as a phonetic process dependent on internal factors. The trajectories of such sound change very much depend on social variables, such as gender, education and the implicit communicative choices of a given language user. The study is partially compatible with the biomechanical interpretation of gender differences. It also corroborated the Labovian gender paradox, especially the hypothesis that social status considerations are correlated with female behaviour in language production and women's resistance to non-prestigious changes compared to men. At the same time, variation in input voicing not only does not inhibit comprehension but seems not to affect output productions in a significant manner. The response to auditory input was positive only in the case of one sound and only when combined with other variables, hence we attribute the observed variation to both phonetic factors (coarticulation, prosody and speech rate) and socially-grounded speaker pronunciation habits. Furthermore, although the comparison of sound weakening by place of articulation showed differences attributable to the articulatory/aerodynamic constraints rather than phonology, all indices taken together, a clear set of weakening degree markers was identified. Voicing, intensity ratio/difference, burst absence rate, consonant duration and the presence of formants appear to be interrelated indicators of lenition regardless of the place of articulation. It further follows from this that the interplay between internal factors (prosody, stress, acoustic parameters) and external elements (gender, education) needs to be explored more deeply to help us understand the phonology of language change.

Acknowledgements

We would like to thank the anonymous reviewers of *Phonetica* and the Editors of this Special Issue for all their suggestions and constructive criticism, wich definitely helped improve the quality of the paper.

Statement of Ethics

The subjects of this study have given their written informed consent and the study was performed in accordance with the protocol and the common practice concerning linguistics research at the University of Warsaw.

Disclosure Statement

The authors have no conflicts of interest to declare.

Funding Sources

The study was partially funded by the University of Warsaw Foundation (05/2015).

Author Contributions

Each of the authors has made a substantial contribution to the conception and design of the submitted work, and participated in drafting, revising and aprroving the final version of the manuscript. In particular, the study was conducted and preprocessed phonetically in Spain. A detailed statistical analysis was then conducted in Poland. The two authors jointly interpreted the results, prepared the paper for publication and accept full responsibility for the contents thereof.

Appendix. List of stimuli

1) He comprado 5 calcetines de Adidas
2) He comprado 5 camisetas de algodón
3) He comprado 5 chanclas de piscina
4) He comprado 5 chicles de fresa
5) He comprado 5 chinchetas de colores
6) He comprado 5 chochos de yema
7) He comprado 5 chocolates con nueces
8) He comprado 5 chocos en salsa
9) He comprado 5 chorizos de Teror
10) He comprado 5 chuletas de cerdo
11) He comprado 5 chupas de bebé
12) He comprado 5 chupitos de vodka
13) He comprado 5 colgadores de toallas
14) He comprado 5 copas de vino
15) He comprado 5 crepes de nutella
16) He comprado 5 crocantes de almendra
17) He comprado 5 croquetas de atún
18) He comprado 5 cuadernos de notas
19) He comprado 5 cuadros de pintura
20) He comprado 5 cuartos de queso
21) He comprado 5 cubos de basura
22) He comprado 5 cuerdas de escalada
23) He comprado 5 kilos de tomates
24) He comprado 5 panes de millo
25) He comprado 5 pantalones de lana
26) He comprado 5 paquetes de azúcar
27) He comprado 5 pares de zapatos
28) He comprado 5 piensos de perro
29) He comprado 5 piezas de fruta
30) He comprado 5 pimientos de padrón
31) He comprado 5 piruletas de coca cola
32) He comprado 5 postres de crema
33) He comprado 5 prendas de ropa
34) He comprado 5 prensas hidráulicas
35) He comprado 5 pruebas de embarazo
36) He comprado 5 puerros de la granja
37) He comprado 5 tapas de tuétano
38) He comprado 5 tarros de garbanzos
39) He comprado 5 tartas de queso
40) He comprado 5 teléfonos de Nokia
41) He comprado 5 tenedores de plástico
42) He comprado 5 terrones de azúcar
43) He comprado 5 tiendas de campaña
44) He comprado 5 tornillos de hierro
45) He comprado 5 tortillas de papa
46) He comprado 5 tostadas de queso
47) He comprado 5 trabas de la ropa
48) He comprado 5 trozos de tarta
49) He comprado 5 truchas de cabello

List of Tables

Table 1. Participant data.

Participant	Age	Sex	Education	Participant	Age	Sex	Education
1H	24	M	university degree	11M	37	F	university degree
2H	26	M	student	12M	24	F	university degree
3M	23	F	student	13H	25	M	university degree
4M	27	F	high school	14M	25	F	university degree
5H	24	M	high school	15M	23	F	student
6H	24	M	university degree	16M	22	F	high school
7H	25	M	university degree	17M	23	F	high school
8H	25	M	high school	18H	27	M	student
9H	33	M	university degree	19M	17	F	high school
10H	25	M	university degree	20H	32	M	university degree

Table 2. Realisations of /p t k tʃ/. Number of words produced with/without voicing, with formants and without burst in the corpus and their respective proportions with respect to all consonants or clusters of a given type expressed in %. Grand total: 1,911 sounds (389 /p/, 388 /t/, 393 /k/, 392 / tʃ/, 117 /pr/, 119 /tr/, 113 /kr/).

Consonant	Voiceless	Partially voiced	Fully voiced	Formants	No burst
/p/	178	73	138	99	132
	45.76%	18.77%	35.48%	25.45%	33.93%
/t/	214	60	114	101	72
	55.15%	15.46%	29.38%	26.03	18.56%
/k/	199	40	154	184	244
	50.64%	10.18%	39.19%	46.70%	61.93%
/tʃ/	232	80	80	43	n/a
	59.18%	20.41	20.41%	10.97%	n/a
/pr/	66	23	28	31	32
	56.41%	19.66%	23.93%	26.50%	27.35%
/tr/	77	16	26	33	18
	64.71%	13.45%	21.85%	27.73%	15.13%
/kr/	60	9	44	50	48
	53.10%	7.96%	38.94%	44.25%	42.48%
Total	1026	301	584	541	548

Table 3. Binary logistic mixed model of voicing as a function of intervocalic sound (/p/, /t/, /k/, /tʃ/), participant gender and education with speaker as a random effect. /p/ is voiced significantly more often than /k/ in university educated females. There are no significant differences in voicing of /p/ and /k/ in males. As for the /tʃ/, university-educated speakers voice it the least often, but there are no significant differences between the voicing of /tʃ/ and the voicing of other sounds in high school speakers.

Gender	Education	Voicing of /p/ compared to:	Estimate	z value	*p value*
Female	High School	/k/	-0.66395	-1.771	0.07660
		/t/	-1.02120	-2.702	0.00689 **
		/tʃ/	-0.71847	-1.847	0.06468
	University	/k/	-1.0526	-3.097	0.00195 **
		/t/	-1.0993	-3.250	0.00115 **
		/tʃ/	-2.7616	-6.279	3.40e-10 ***
Male	High School	/k/	0.44336	1.058	0.28995
		/t/	-0.31205	-0.777	0.43721
		/tʃ/	1.20026	2.510	0.01208 *
	University	/k/	0.05501	0.197	0.84361
		/t/	-0.38975	-1.436	0.15111
		/tʃ/	-0.84295	-3.107	0.00189 **

Sound	Education	Voicing of /tʃ/ compared to:	Estimate	z value	p value
/tʃ/	High School	/p/	0.71942	1.850	0.064341
		/t/	-0.30204	-0.762	0.446329
		/k/	0.05524	0.140	0.888709
	University	/tʃ/	-3.02824	-2.824	0.004739 **
		/p/	2.7618	6.283	3.33e-10 ***
		/t/	1.6625	3.761	0.000169 ***
		/k/	1.7092	3.848	0.000119 ***

Table 4. Mean durations of voiced and voiceless outputs in ms.

Consonant	Voiceless	Partially and fully voiced	Difference in ms	% difference
/p/	0.084	0.064	0.02	23.8
/t/	0.08	0.061	0.019	23.7
/k/	0.086	0.06	0.026	30.2
/tʃ/	0.101	0.077	0.024	23.7
Total	0.087	0.064	0.023	26.4

Table 5. Comparison of separate generalized linear mixed models of voicing for each sound. '-' means that the effect did not enter the model

Sound in the model	Presence of stress (df=1)	Presence of burst (df=1)	Presence of formants (df=1)	Gender (male) (df=1)	Formant*Gender (male) (df=1)
/p/	beta = -1.395 z = -4.132 *p* < 0.0001	-	-	-	-
/t/	beta = -0.996 z = -3.318 *p* < 0.001	beta = -1.860 z = -3.308 *p* < 0.001	beta = 1.660 z = 3.629 *p* < 0.001	-	-
/k/	-	beta = -1.200 z = -2.733 *p* < 0.01	beta = 3.789 z = 4.770 *p* < 0.0001	beta = 1.827 z = 2.488 *p* < 0.05	beta = -1.739 z = -1.904 *p* = 0.057

Sound in the model	Presence of stress (df=1)	University education (df=1)	Gender (male) (df=1)	Voiced input (df=1)
/tʃ/	beta = -1.084 z = -3.146 *p* < 0.01	beta = -3.854 z = -2.145 *p* < 0.05	beta = 4.852 z = 2.775 *p* < 0.05	beta = 0.662 z = 1.978 *p* < 0.05

List of Figures

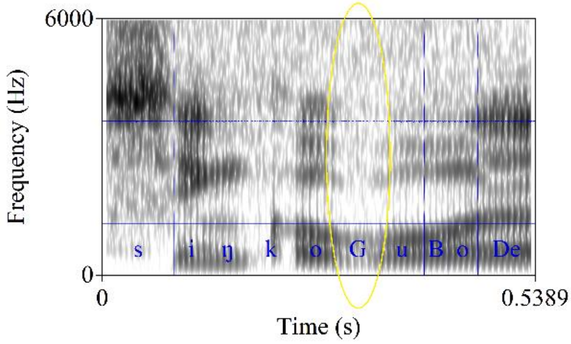

Fig. 1. Spectrogram of the words *cinco cubos* ‘five bins’ presenting slight approximantisation (some formants visible). Capital letters designate approximantised consonants.

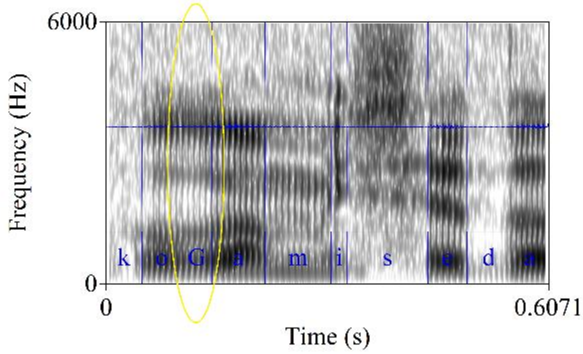

Fig. 2. Spectrogram presenting the word *camisetas* ‘T-shirts’ presenting strong approximantisation (all formants visible). Capital letters designate approximantised consonants.

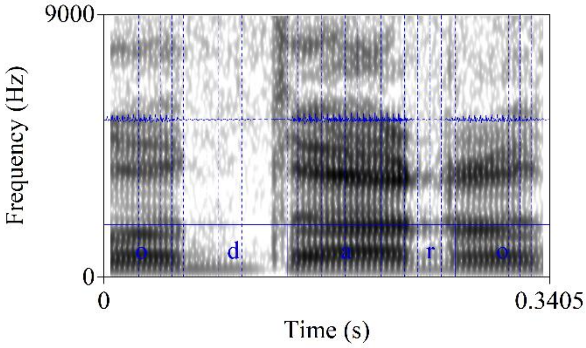

Fig. 3. Spectrogram of the word *tarros* ‘jars’ presenting partial voicing (speaker 5).

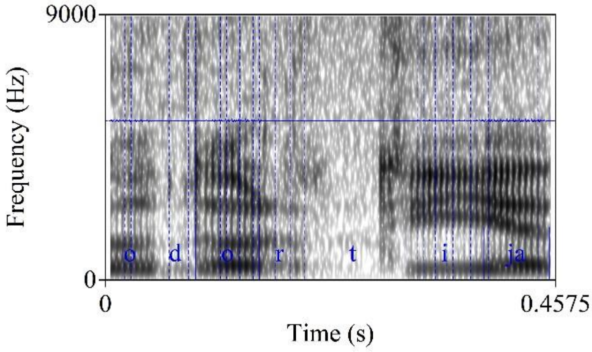

Fig. 4. Spectrogram of the word *tortillas* ‘omelettes’ presenting full voicing (speaker 5).

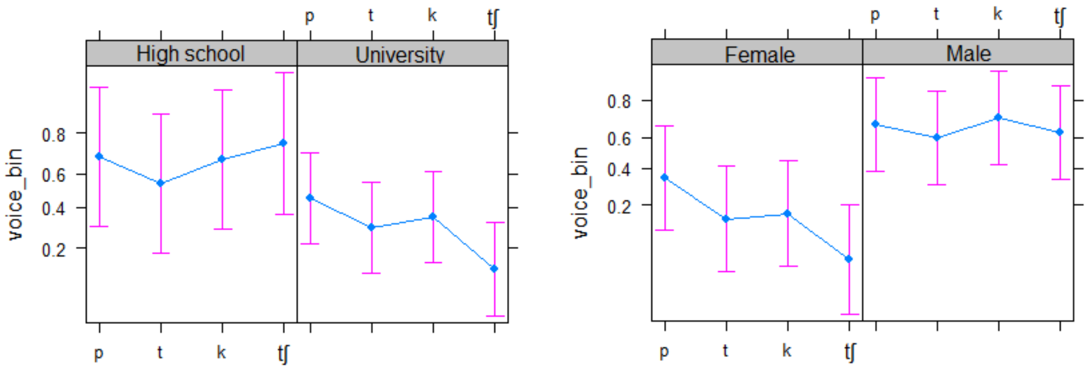

Fig. 5. Effect plots of sound*education (left) and gender*sound (right) interactions (mean predicted probabilities from the model).

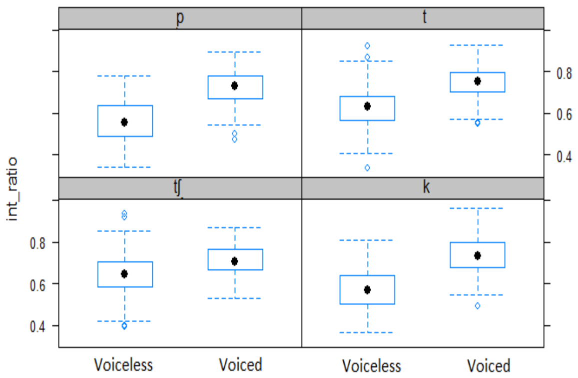

Fig. 6. Differences in the intensity ratio per sound depending on the voicing.

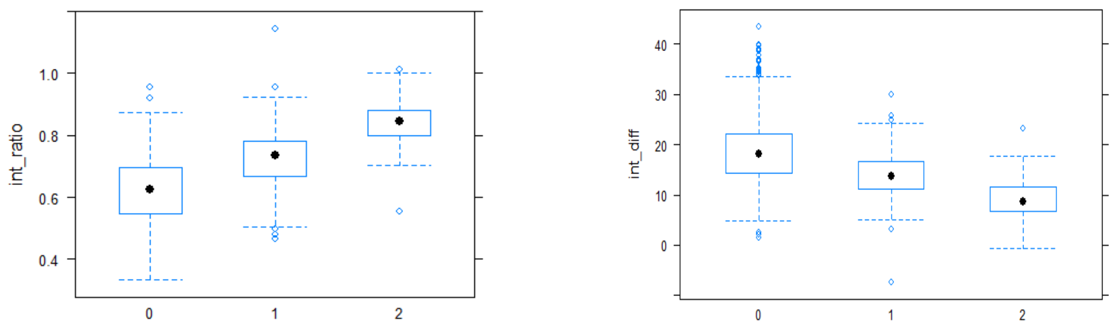

Fig. 7. Differences in the intensity ratio (left) and intensity difference (right) dependent on the presence/absence of formants. The boxplots are based on /p t k/ data. Slight to medium presence of formants is coded as {1}, strong formants throughout the duration of the sound are marked {2}.

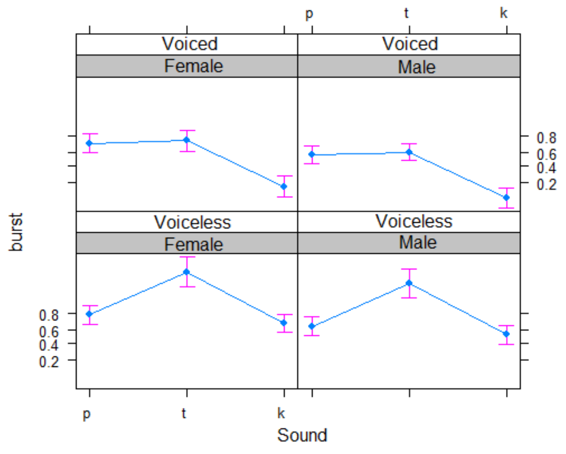

Fig. 8. Probability of burst occurrence by sound, voicing and participant gender.

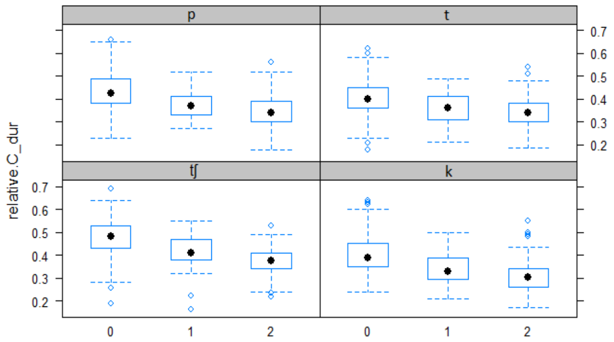

Fig. 9. Differences in relative consonant duration values per sound depending on the voicing. Voiceless productions are coded as {0}, partially voiced tokens as {1}, and fully voiced sounds as {2}.

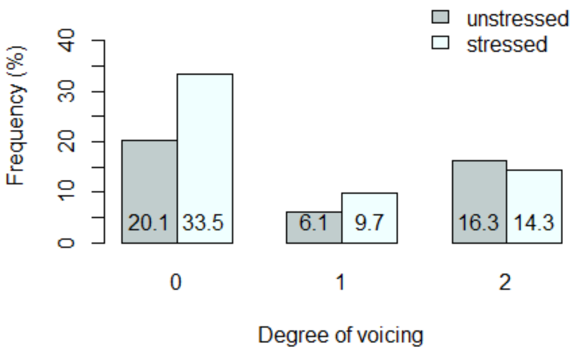

Fig. 10. Differences in the rates of voicing depending on stress. Partial voicing is coded as {1}, full voicing corresponds to {2}.

References

Álvar, M. & Quilis. A. (1966). Datos acústicos y geográficos sobre la *ch* adherente de Canarias. *Anuario de Estudios Atlánticos 12(1):* 337-343.

Bates, D., Maechler, M., Bolker, B., & Walker, S. (2018). lme4: Linear mixed-effects models using Eigen and S4. R package version 1.1–17. Retrieved from https://cran.r-project.org/web/packages/lme4/lme4.pdf.

Broś, K. (2016a). Between phonology and morphosyntax: voicing and spirantization in the Spanish of Gran Canaria. *In* E. Cyran & J. Szpyra (eds.) *Phonology, its faces and interfaces*. 173-200. Frankfurt am Main: Peter Lang.

Broś, K. (2016b). Stratum junctures and counterfeeding: Against the current formulation of cyclicity in Stratal OT. In Ch. Hammerly & B. Prickett (eds.), *Proceedings of the Forty-Sixth Annual Meeting of the North East Linguistic Society*. 157–170.

Cabrera Abreu, M. & F. Vizcaíno Ortega. (2010). Canarian Spanish Intonation. In Pilar Prieto & Paolo Roseano (eds.), *Transcription of Intonation of the Spanish Language*. 87–122. Munich: Lincom Europa.

Carrasco, P., Hualde, J.I & M. Simonet. (2012). Dialectal Differences in Spanish Voiced Obstruent Allophony: Costa Rican versus Iberian Spanish. *Phonetica 69:*149–179.

Cho,T. (2016). Prosodic boundary strengthening in the phonetics-prosody interface. *Language and Linguistics Compass 10(3):* 120–141.

Colantoni, L. & Marinescu, I. (2010). The scope of stop weakening in Argentine Spanish. In Ortega-Llebaria (ed.), *Selected Proceedings 4th Conference on Laboratory Approaches to Spanish Phonol*ogy. 100–114. Sommerville: Cascadilla Press.

Dalcher, Ch. (2008). Consonant weakening in Florentine Italian: A cross-disciplinary approach to gradient and variable sound change. *Language Variation and Change 20:*275–316.

Dorta, J. (1997). Datos acústicos y percepcion de la /c/ adherente de Canarias y de la prepalatal castellana. In Manuel Almeida & Josefa Dorta (eds.), *Contribuciones al estudio de la lingüística hispánica (Homenaje al profesor Ramón Trujillo)*. 57-72. Barcelona: Montesinos.

Eckert, P. (1989). The whole woman: sex and gender differences in variation. *Language Variation and Change 1*: 245-67.

Fox, J. (2003). Effect Displays in R for Generalised Linear Models. *Journal of Statistical Software, 8(15)*: 1-27. URL http://www.jstatsoft.org/v08/i15/.

Fougeron, C. & Keating, P. (1997). Articulatory strengthening at edges of prosodic domains. *Journal of the Acoustical Society of America 106*: 3728–40.

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

Gurevich, N. (2004). *Lenition and Contrast: The Functional Consequences of Certain Phonetically Conditioned Sound Changes.* New York: Routledge.

Guy, G. (2003). Variationist approaches to phonological change. In B. Joseph & R. Janda (eds.) *The Handbook of Historical Linguistics*. 369-400. Oxford: Blackwell.

Herrera Santana, J. (1989). Sonorizacióm de oclusivas sordas en Tenerife. In Josefa Dorta & Juana Herrera (eds.), *Tres estudios de Fonética*. 111-121. La Laguna: Universidad de La Laguna.

Herrera Santana, J. (1997). Estudio acústico de /p, t, c, k/ y /b, d, y, g/ en Gran Canaria. In Manuel Almeida & Josefa Dorta (eds.), *Contribuciones al estudio de la lingüística hispánica (Homenaje al profesor Ramón Trujillo)*. 73-86. Barcelona: Montesinos.

Hualde J.I. & Nadeu M. (2011). Lenition and phonemic overlap in Rome Italian. *Phonetica 68*:215–242.

Hualde, J.I., Nadeu, M. & M. Simonet (2010). Lenition and phonemic contrast in Majorcan Catalan. In Colina, Olarrea, Carvalho (eds.), *Romance Linguistics 2009. Selected papers from the 39th Linguistic Symposium. on Romance Languages*. 63–79. Amsterdam: John Benjamins.

Hualde J.I., Simonet M. & M. Nadeu (2011). Consonant lenition and phonological recategorization. *Laboratory Phonology 2:*301–329.

Hume, E., & Johnson, K. (2001). A model of the interplay of speech perception and phonology. In E.Hume & K. Johnson (eds.), *The role of speech perception in phonology*. 3–26. New York: Academic Press.

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

Labov, W. (1980) The social origin of sound change. In William Labov (ed.), *Locating Language in Time and Space*. 251-66. New York: Academic Press.

Labov, W. (1990). The intersection of sex and social class in the course of linguistic change. *Language Variation and Change 2*:205-254.

Labov, W. (1994). *Principles of Linguistic Change. Volume 1: Internal Factors*. Oxford: Basil Blackwell.

Labov, W. (2001). *Principles of Linguistic Change.* Vol.2: *External Factors*. Oxford: Blackwell.

Labov, W. (2006). A sociolinguistic perspective on sociophonetic research. *Journal of Phonetics 34*:500-15.

Lavoie, L. (2001). *Consonantal Strength: Phonological Patterns and Phonetic Manifestations*, New York: Routledge.

Lewis A.M. (2001). *Weakening of Intervocalic /ptk/ in Two Spanish Dialects: Toward the Quantification of Lenition Processes*. PhD dissertation, University of Illinois at Urbana-Champaign.

Lloyd, P.M. (1987). *From Latin to Spanish*. American Philosophical Society.

Loporcaro, M. (2009). *Profilo linguistico dei dialetti italiani*. Bari: Laterza.

Lucero, J., & Koenig, L. (2005). Phonation thresholds as a function of laryngeal size in a two-mass model of the vocal folds. *Journal of the Acoustical Society of America*, *18*: 2798–2801.

Machuca Ayuso M.J. (1997). *Las obstruyentes no continuas del español: relación entre las categorías fonéticas y fonológicas en habla espontánea*. PhD dissertation. Universitat Autònoma de Barcelona.

Marrero, V. (1986). *Fonética estática y fonética dinámica en el habla de las Islas Canarias*. PhD dissertation. Universidad Complutense de Madrid.

Martínez Celdrán, E. (1993). La percepción categorial de /b, p/ en espanol basada en las diferencias de duración. *Estudios De Fonética Experimental 5*:223–239.

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

Morera, M. (1990). *Unidad y variedad del español de Canarias.* La Laguna: Universidad de La Laguna.

Nadeu, M. & Hualde, J.I. (2015). Biomechanically conditioned variation at the origin of diachronic intervocalic voicing. *Language and Speech 58(3):* 351-370.

Oftedal, M. (1985). *Lenition in Celtic and in Insular Spanish*. Universitetsforlaget Oslo.

Ohala, J. (1981). The listener as a source of sound change. In Masek, C.S., R.A. Hendrik, M. F. Miller (eds.), *Papers from the Parasession on Language and Behavior.* 178-203. Chicago Linguistics Society. Chicago: CLS.

Ohala, J. (1983). The origin of sound patterns in vocal tract constraints. In P.F. MacNeilage (ed.), *The production of speech*. 189–216. New York: Springer-Verlag.

Ohala, J. (1990). The phonetics and phonology of aspects of assimilation. In J. Kingston & M. Beckman (eds.), *Papers in Laboratory Phonology 1*. 258-275. Cambridge: Cambridge University Press.

Parrell, B. (2010). Articulation from acoustics: estimating constriction degree from the acoustic signal. *Journal of the American Acoustical Society 128(4):*2289.

Parrell, B. (2011). Dynamical account of how /b, d, g/ differ from /p, t, k/ in Spanish: Evidence from labials. *Laboratory Phonology 2(2)*:423–449.

Prieto, P. 2007. Phonological phrasing in Spanish. In F. Martínez-Gil & S. Colina (eds.), *Optimality-Theoretic Studies in Spanish Phonology*. 39-61. Amsterdam & Philadelphia: John Benjamins.

R Core Team (2017). R: A language and environment for statistical computing. *R Foundation for Statistical Computing*, Vienna, Austria. URL https://www.R-project.org/.

Recasens, D. (2002), Weakening and strengthening in Romance revisited. *Rivista di Linguistica 14*: 327–373.

Romero, J., Parrell, B. & M. Riera (2007). What distinguishes /p/, /t/, /k/ from /b/, /d/, /g/ in Spanish? Poster presented at Phonetics and Phonology in Iberia. Braga, Portugal.

Shadle, C.H. (1997). The aerodynamics of speech. In W. Hardcastle & J. Laver (eds.), *The handbook of phonetic sciences.* 39–80. Oxford: Blackwell.

Torreblanca M. (1976). La sonorización de las oclusivas sordas en el habla toledana. *Boletín De La Real Academia Española 56:*117–146.

Torreira, F. & M. Ernestus (2011). Realization of voiceless stops and vowels in conversational French and Spanish. *Laboratory Phonology 2.2*: 321–354.

Trudgill, P. (1972). Sex, Covert Prestige and Linguistic Change in the Urban British English of Norwich. *Language in Society 1 (2):*175–195.

Trujillo R. (1980). Sonorización de sordas en Canarias. *Anuario Letras 18*:247–254.

Vennemann, T. (1988). *Preference laws for syllable structure and the explanation of sound change*. Berlin: Mouton de Gruyter.

Zec, D. (1995). Sonority constraints on syllable structure. *Phonology 12*:85–129.