

Reinterpretation of biomechanics as gender-conditioned variation in the origin of diachronic intervocalic voicing

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1. Introduction

In this paper we test the hypothesis that individual variation that has its origins in biomechanics may be reinterpreted as socially-constructed, setting the stage for possible sound change if the innovative pattern later spreads throughout the language community. The phenomenon that we study is intervocalic stop voicing. Specifically, the hypothesis is the following: A larger larynx or faster speech makes it more difficult to control the cessation of voicing in intervocalic contexts (Lucero & Koenig 2005). Since there is a correlation between male sex and a larger larynx, there is a possibility that voiced realizations may be reinterpreted as intended (à la Ohala 1981, etc.) markers of male speech, eventually potentially spreading to both genders and providing the basis for rephonologization (e.g. /p/ > /b/).

2. Intervocalic obstruent voicing in Iberian Spanish: inter-speaker variation

Spanish and the languages that are in contact with it in the Iberian Peninsula, Catalan, Galician, and Basque, share a generalized process of lenition of the voiced plosives /b d g/. In postvocalic and some postconsonantal contexts these consonants are systematically realized without full occlusion, as approximants, in these languages. This process has been referred to as ‘Iberian spirantization’ (Mascaró 1991), since it is found in these Ibero-Romance languages and Basque, although with some differences in the details.

A more incipient phenomenon, also shared by these languages to some extent, is the voicing of intervocalic /p t k/. From a phonological point of view, it is interesting because it could potentially result in neutralization with /b d g/. This phenomenon is less well known than the lenition of /b d g/ and is far from having the same systematic character. In fact, linguists have become aware of the phenomenon only through spectrographic analysis (Torreblanca 1976, 1979; Trujillo 1980; Oftedal 1985; Machuca 1997; Lewis 2001; Martínez Celdrán 2009; Hualde, Simonet & Nadeu 2011; Torreira & Ernestus 2011). Nevertheless, this is arguably a conventionalized process of reduction in these languages, beyond expected phonetic variability. Torreira & Ernestus (2011), comparing two very similar corpora of casual Spanish and French, conclude that intervocalic voicing of /p t k/ is a much more pervasive process in Spanish than in French, where it is only sporadic.

Acoustic studies of the phenomenon in different Spanish varieties have found considerable variation in the frequency with which intervocalic /p t k/ are voiced both in different areas and by different speakers of the same geographical variety. Thus, Machuca (1997), who examines the realization of intervocalic /p t k/ in unscripted conversation by four native Spanish speakers from Barcelona, Spain, reports that the percentage of voiced tokens ranges from 34.9% to 64.6%, depending on the speaker. Lewis (2001) finds considerable differences in percentage of intervocalic voicing between speakers from Bilbao, Spain, and Colombian speakers from Bogotá and Medellín. He reports the percentage of the occlusion of the consonant that is voiced on average, and finds about 55% of voicing for his four Bilbao speakers but only about 10% for his Colombian speakers. For both groups averages are much lower in reading styles. Martínez Celdrán (2009), for one speaker from Murcia, in southern Spain, finds 74.4% of voiced realizations of /p t k/, of which 15.9% are classified as approximants. Torreira & Ernestus (2011)

report an overall percentage of voicing of 32.7% for 52 young speakers from Madrid engaged in casual conversation. Hualde et al. (2011) report 22% of fully voiced realizations of intervocalic /p t k/ for 20 native Spanish speakers from Majorca participating in semi-spontaneous speech, but point out that the percentage was very low, 3.6%, when the same twenty speakers were recorded in a reading task. They also notice that four of their speakers had percentages of fully or partially voiced tokens of /p t k/ higher than 60% in spontaneous speech. In an unpublished poster presentation, the same authors report less lenition in Majorcan Catalan than in Majorcan Spanish (Hualde, Simonet & Nadeu 2010).

It thus appears that, although intervocalic /p t k/ undergo voicing in a number of Spanish dialects and the languages that are in contact with Spanish, there is much variation in the frequency of lenition of /p t k/. Some of this variation clearly has to do with the formality or casualness of the style. Differences in overall frequency of voicing among studies also indicate the existence of differences among languages and geolcts. But there are also reports of individual variation whose source has remained unexplored. A question that these findings raise is whether the variable voicing of /p t k/ may have acquired sociolinguistic significance for speakers, even though the phenomenon remains below the level of linguistic awareness.

We have reanalyzed the unscripted speech data in Hualde et al. (2011), obtaining percentages of voiced tokens by speaker and separating by the sex of the speaker. The results are shown in Figure 1. The “voiced” category includes both tokens that present uninterrupted voicing during the duration of the consonant (as shown by the pulse display and the F0 curve in Praat, Boersma [2001]) and tokens that show voicing during most of the occlusion, but where voicing is interrupted in the release phase of the consonant. Figure 1 shows that there is indeed a great amount of variation among the 20 speakers in their implementation of voicing of /p t k/ in intervocalic position. Inter-speaker variation ranges from about 5% of voiced tokens for three speakers to about 75% for three others. Comparing the two panels in this figure, it is also apparent that an important factor in this variation seems to be the speaker’s sex, with males presenting an overall higher percentage of voiced tokens, although a few speakers go against the general trend for their sex.

The voicing of intervocalic obstruents in Iberian Spanish also affects fricatives. Torreira & Ernestus (2012) report that over a third (34%) of intervocalic tokens of /s/ in their corpus of casual Madrid Spanish (conversations between friends) show uninterrupted voicing. They also report much variation among their 52 speakers in this respect: “most speakers in our data had a voicing rate below 20%, including a few who rarely voiced their consonants, and one who never did. High rates of voicing were not uncommon in the data either, with eight of the 52 speakers exhibiting voicing rates over 50%, and reaching 80% for two speakers” (p. 137). As in the study of /p t k/ voicing in Hualde et al. (2011), males show, in average, twice as much voicing of /s/ than females, see Figure 2.

3. Voicing of intervocalic /p t k/ in Basque

The same intervocalic lenition phenomenon as in Iberian Spanish is found, at a somewhat more advanced stage, in Basque varieties (Salaburu 1984). We analyzed digital recordings of semi-directed conversations with 12 speakers of Basque (balanced by gender) from the small town of Goizueta, in northwestern Navarre. The interviewer was also from Goizueta and the recorded conversations are on everyday topics. From each interview, we extracted all intervocalic tokens of /p t k/ and /b d g/ produced during the first five minutes of the recording. A

total of 1211 consonants were segmented and entered in the analysis. A segment was classified as voiced or partially voiced as described in Section 2.

As shown in Table I (see also Figure 3), almost 34% of all instances of intervocalic /p t k/ were realized as fully voiced (in this corpus “partially voiced” tokens were exceedingly few). There are also clear differences among the three phonemes, with /k/ leading in the voicing (notice incidentally that /p/ is not a frequent phoneme in Basque).

Table I. Distribution of voiced and voiceless allophones of /p t k/ in Goizueta Basque.

	Voiceless	Voiced	Total
/p/	59 (68.6%)	27 (31.4%)	86
/t/	444 (77.8%)	127 (22.2%)	571
/k/	297 (53.6%)	257 (46.4%)	554
Total	800 (66.1%)	411 (33.9%)	1211

Regarding interspeaker variation, we find that men realize these consonants as fully voiced twice as frequently as women do (47% vs. 23%), although there are important differences among speakers of the same sex (see Figure 4). The results thus show the same pattern as in the studies of intervocalic voicing in Spanish reviewed in Section 2.

This phonetic variation may have a biological basis: The larger average size of men’s larynxes may result in a more difficult control of cessation of voicing in the intervocalic context (Lucero & Koenig 2005). However, this does not preclude its being also socially constructed (Foulkes & Docherty 2006 on laryngealization in Newcastle English). Full voicing does in fact go beyond a biophysical tendency for voice leakage from the preceding vowel. Unlike in the phenomenon studied by Foulkes & Docherty, the voicing of /p t k/ seems to be below speakers’ awareness in both Spanish and Basque. Another, complementary, hypothesis is that differences among speakers are due to speech rate: Faster speech results in more voicing.

4. Voicing and speech rate

To test the hypothesis that voicing is under speaker control, with sociolinguistic value, we have conducted a follow-up experiment. We reason that if full intervocalic voicing is a purely mechanical phenomenon, it should increase with speech rate (and shorter consonant duration), whereas a poor correlation between voicing and tempo/duration would provide evidence for the conventionalization of the phenomenon in the speech of individuals at the vanguard of the sound change. We asked four male and four female speakers of Iberian Spanish to produce non-words (to avoid possible lexical effects) like /pipe/ in a carrier phrase at two speeds, normal and fast.

Results show that, as expected, speakers produced more fully voiced tokens in the fast rate condition than in the normal speaking condition (21.58% vs. 1.13% of voiced tokens respectively, $\chi^2[1]=29.96$, $p<0.001$, see Figure 5). In addition, partially voiced tokens showed a longer percentage of voicing during occlusion in the fast speaking rate condition (mean = 69.01%, SD = 19.21) than in the normal condition (50.59%, SD = 13.06). The coefficients obtained from a linear-mixed effects model with Percentage of Voicing as response, Speech Rate (normal, fast) and Gender as fixed effects, and Speaker as a random effect (with by-speaker slopes for Speech Rate) are shown in Table II. As shown in the table, at normal speech rate the percentage of voicing during occlusion is lower than at faster speech. Figure 6 shows that this is the case for all eight speakers. There was no significant effect of gender.

Table II. Regression coefficients and t values for the linear mixed-effects model with percentage of voicing as response. The intercept corresponds to /p/ produced by women in the fast speech rate condition.

Term	Level	β	t
Intercept		64.40	
Speech Rate	Normal	-14 .25	-2.43*
Gender	Male	9.34	0.98
Speech Rate * Gender	Normal, Male	-8.41	-1.02

Important individual differences are nevertheless maintained across styles. Speaking at a faster rate does not eliminate the difference between “voicers” and “non-voicers”. In our data, two female (F01 and F04) and two male (M02 and M04) speakers produced voiced realizations of /p t k/ more often than the other four (see Figure 7 and Table III). If we compare these four “voicers”, we notice that the two male speakers produced voiced /p t k/ considerably more often than the female speakers did. In fact, the difference in frequency of voicing between male and female speakers (all eight speakers) is significant ($\chi^2[1]=165.81, p<0.001$).

Table III. Count of voiced and voiceless tokens of intervocalic /p/ produced by each of eight Spanish speakers.

	Voiced	Voiceless	Total
F01	25	175	200
F02	3	197	200
F03	6	194	200
F04	22	177	199
M01	3	197	200
M02	43	157	200
M03	7	193	200
M04	72	124	296

We conclude that a preference for frequent full-voicing of intervocalic /p t k/ is a trait of individual speakers and is not simply a result of a faster elocution. Perhaps because of biomechanical reasons, males show, in general, a greater propensity to voice in intervocalic position. The propagation of this preference for voicing through the language community, perhaps initially as a gender marker, could result in a progressive preference for intervocalic voicing of stops, as we find in the history of many languages (e.g Lat. *lupu* > Sp. *lobo* ‘wolf’).

5. Summary/conclusions

- Intervocalic voicing of obstruents is a somewhat conventionalized process of phonetic reduction in the languages under study (as opposed to, e.g., French where the phenomenon has much lower incidence).
- Partial voicing may be biomechanically conditioned by factors such as a larger larynx and/or faster articulation.
- A sex-correlated propensity to voice may be interpreted as a marker of male gender, leading to even greater tendency to voice among males. This more frequent production of voiced allophones would be intentional even if it is below awareness.

- Later, a preference for voiced variants may lose its connection to male gender and spread to both genders, eventually resulting in sound change.

Figures

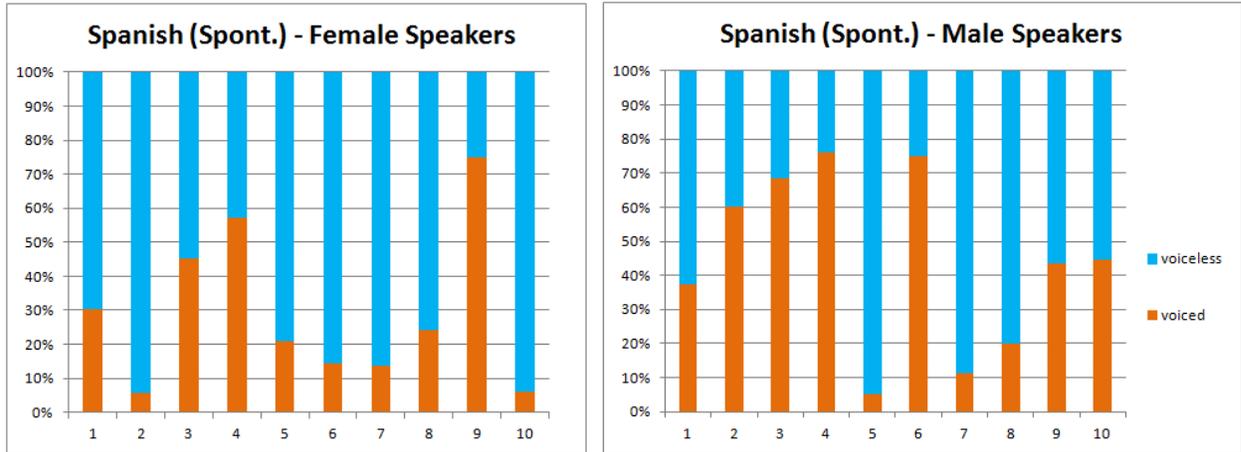


Fig. 1. Percentage of voiced and voiceless realizations of intervocalic /p t k/ in unscripted conversation in Spanish (data from Hualde et al. 2011).

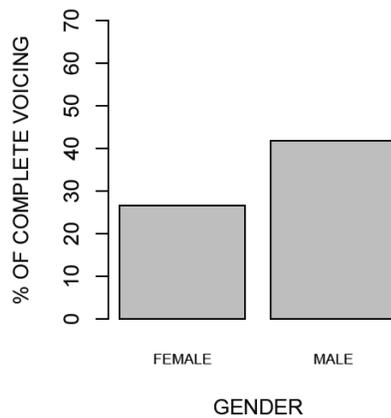


Fig. 2. Percentage of intervocalic tokens of /s/ with complete voicing by gender (52 speakers, from Torreira & Ernestus 2012, figure courtesy of F. Torreira).

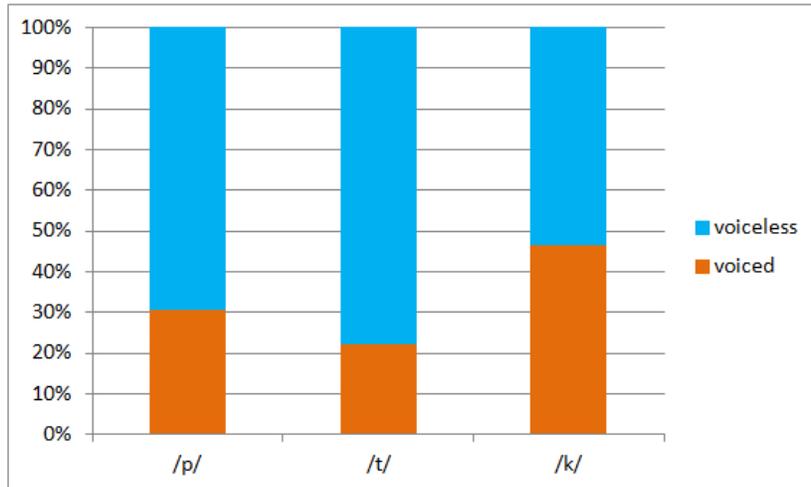


Fig. 3. Percentage of voiced and voiceless realization of intervocalic /p t k/ in Goizueta Basque (all speakers combined).

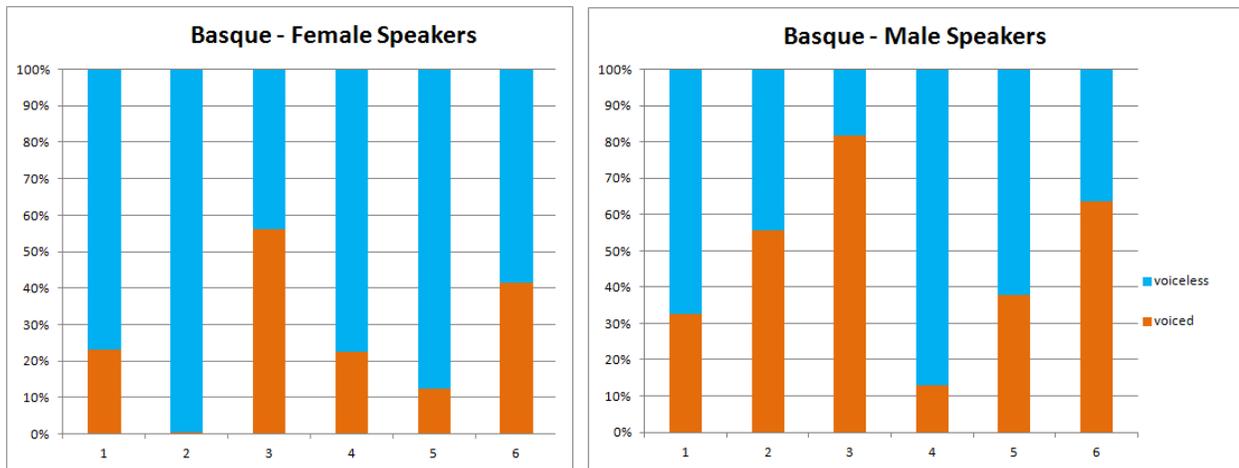


Fig. 4. Percentage of voiced and voiceless realizations of intervocalic /p t k/ produced by 12 speakers (six female, left panel) of Goizueta Basque.

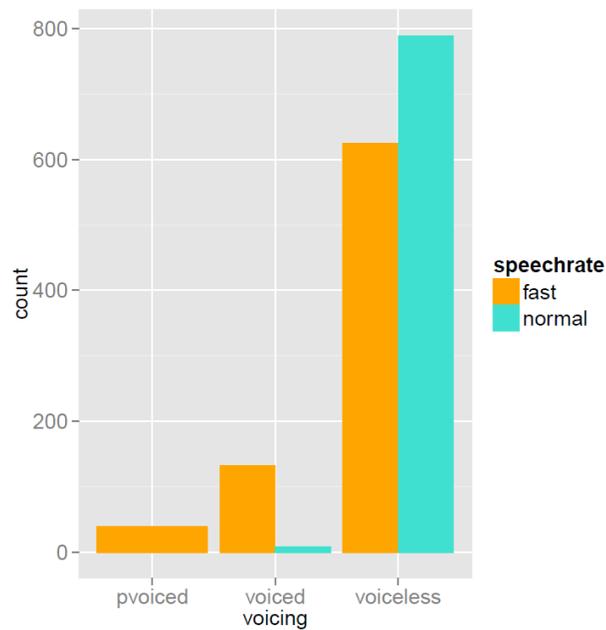


Fig. 5. Frequency of partially voiced (“pvoiced”), voiced, and voiceless realizations of /p/ at fast and normal speech rate in Spanish.

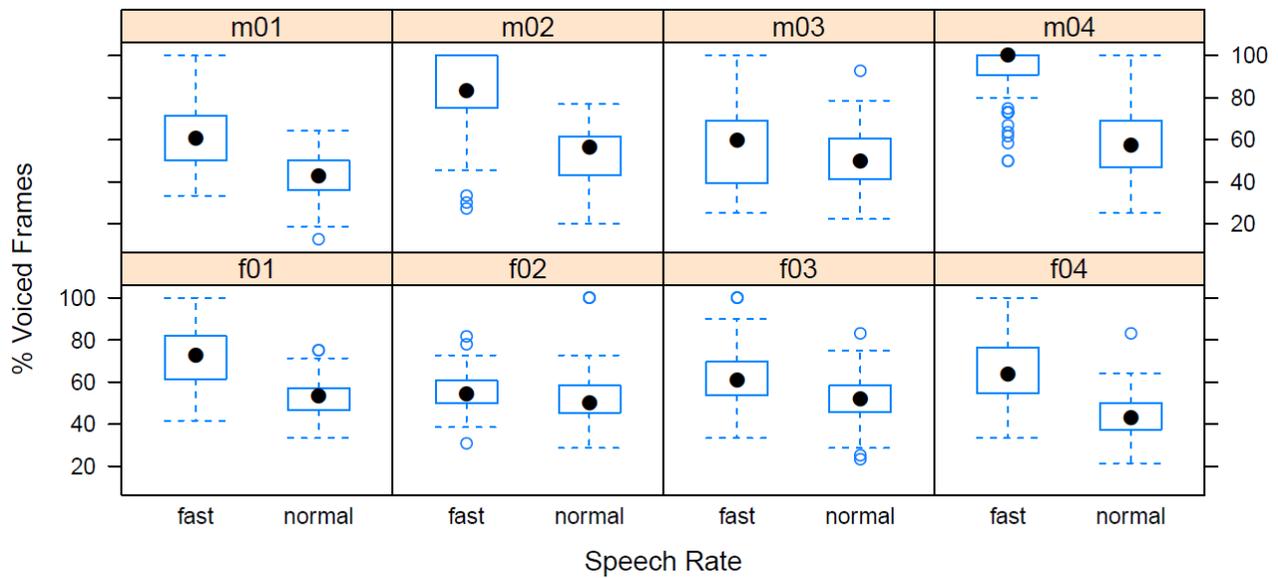


Fig. 6. Percentage of voicing during /p/ occlusion for eight speakers (an initial “m” indicates male speakers) of Spanish.

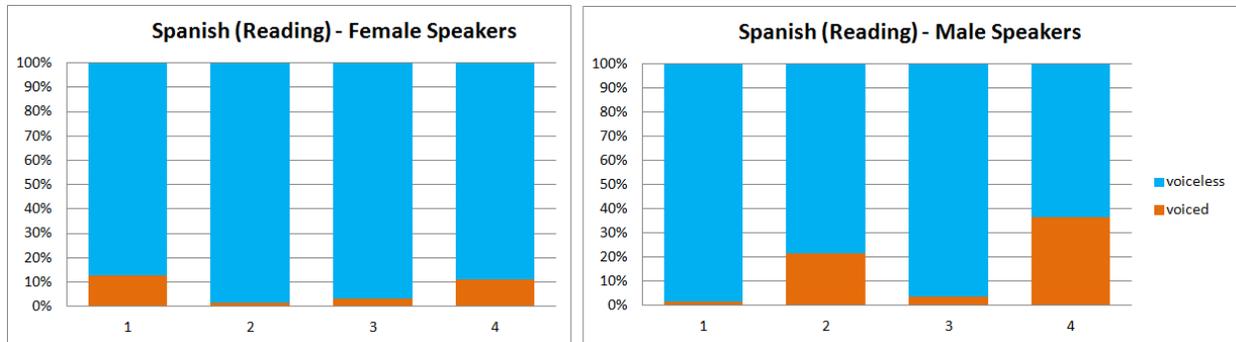


Fig. 7. Percentage of voiced and voiceless realizations of intervocalic /p/ in read speech produced by eight speakers of Spanish (four female, left panel).

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