


Phonetic reduction processes in spontaneous speech

Beatriz Blecua

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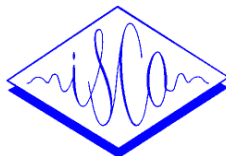


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PHONETIC REDUCTION PROCESSES IN SPONTANEOUS SPEECH

L. Aguilar, B. Blecua, M. Machuca, R. Marín

Departament de Filologia Espanyola
Universitat Autònoma de Barcelona
Barcelona, Spain
e-mail: ilfh6@cc.uab1.es

西班牙语中自发产出的辅音分析，语音过程分析，低水平语音弱化，并藉此分辨不同语音风格。

ABSTRACT

Phonetic analysis of the speaking styles can involve the study of the differences in the manifestation of phonetic processes. The aim of this work is to observe and classify low-level reduction processes affecting consonants by means of an acoustic and auditive analysis of a sample of spontaneous speech in Spanish. A continuum of articulatory reduction arises out of the data. Moreover, the acoustic behaviour of the processes helps to establish differences between speaking styles.

Keywords: *Phonetic reduction processes, consonants, spontaneous speech, Spanish.*

1. INTRODUCTION

Phonetic analysis of the speaking styles can involve the characterisation of suprasegmental and segmental features in a given style, the comparison over various styles or even the study of the differences in the manifestation of phonetic processes. In this work, we will focus on the last point of view in order to observe and classify phonetic processes in spontaneous speech in Spanish.

According to Harris [1], phonological processes for Spanish are: vowel-glide-consonant alternation, weakening of voiced stops, assimilation of laterals and nasals, and voicing of [s]. From a more phonetic approach, voice, place and manner assimilation, weakenings, cluster simplifications and vowel reductions are described by Navarro Tomás [4].

But depending on the speaking style chosen, phonological processes can be manifested in different ways: in the so-called "laboratory speech", only a phonetic result is expected, but if spontaneous speech is analysed, a large variability can be observed. These varying results are treated like phonetic processes.

The acoustic analysis of samples of spontaneous speech is intended to bear light on the study of low-level phonological properties in speaking styles. The aim of the analysis is to determine the reduction processes which affect consonants in a hypoarticulated speech [3].

2. EXPERIMENTAL PROCEDURE

2.1. Corpus

The corpus consists of four interviews made to four different speakers: in the first half, the researcher and the speaker have an interactive relation (dialogue), while in the other half the researcher only participates when the speaker has finished the topic (nearly a monologue). This design allows to compare, on the one hand, the differences due to the speaking conditions and, on the other hand, those depending on the speaker.

The interviews were recorded in a semi-anechoic room, of quite large dimensions so as to create the most favourable circumstances for carrying on a normal conversation, with a Tascam 112 and a Sennheiser microphone. A relationship existed between interviewer and interviewees, and all subjects were familiar with the recording environment.

Twenty minutes of each recording have been excerpted for the analysis. In the monologue cases, parts of greater spontaneity have been chosen. Henceforth, speakers will be designed with their initials: R., I., J. C. and P. L. The first two were recorded in a dialogue situation and the other two in a monologue one.

2.2. Analysis

Phonetic processes have been observed firstly in an auditive way in order to make a narrow phonetic transcription. Secondly, the behaviour of these processes has been acoustically determined by means of oscillograms and spectrographs using the speech analysis system Mac Speech Lab. However, the object was not the quantification of the acoustic facts but an observation was only required for deciding assimilation, voicing, unreleasing, deletion cases and so on.

Finally, the frequency of occurrence of each phenomena is the parameter used to differentiate between speakers and styles. Only consonants inside a content word have been taken into account, due to the different behaviour displayed by function words versus content words. Stops, approximants, fricatives, trills, flaps and affricates are the analysed consonants. Nasals and laterals have not been considered.

3. RESULTS

The data are organised depending on the consonantal manner of articulation. Different acoustic manifestations are shown for each group of consonants.

3.1. Stops

3.1.1. Voiceless stops

At least five different manifestations of voiceless plosives /p, t, k/ have been identified: a) plosive realised according to its acoustic characteristics with a silence followed by a burst, b) unreleased stop appearing without the burst, c) voiced stop, d) approximant and e) deletion.

This series can be considered a continuum of articulatory reduction, from a maintenance of the consonant to deletion. The tendency towards a result will strongly depend on the surrounding context and on the speaking style.

In intervocalic environment, two different groups can be established if the speakers' data are compared: speakers J. C. and P. L., whose interviews approach the monologue condition, show a strong tendency to keep voiceless stops whereas speakers R. and I., who have performed a real dialogue with the researcher, present unreleased voiceless stops, voiced stops and approximants in a high percentage (see table I).

However, as it can be inferred from the table, there are differences between the consonants for R. and I.: /p/, /t/ tend to be voiced while /k/ tends to the approximant realisation in R's data; on the contrary, /p, t, k/ show a majority of unreleased variants in I.

		DIALOGUE		MONOLOGUE	
		R.	I.	J. C.	P. L.
/p/	voiceless stop	26.9	21.0	96.6	94.6
	unreleased	9.5	63.0	1.1	1.1
	voiced stop	54.7	10.0	2.2	3.2
	approximant	6.9	5.9		1.1
	deletion	1.7			
/t/	voiceless stop	26.2	42.0	90.6	87.3
	unreleased	11.8	46.0	3.2	5.2
	voiced stop	49.9	6.7	4.3	5.9
	approximant	10.0	4.6	1.4	1.5
	deletion	1.8			
/k/	voiceless stop	21.6	27.8	83.1	76.7
	unreleased	7.9	49.3	6.7	11.9
	voiced stop	17.9	4.5	3.5	8.2
	approximant	47.6	18.2	6.5	3.1
	deletion	4.5			

Table I. Frequency of occurrence (in %) of the realisations of /p, t, k/ in intervocalic context for the four speakers.

The post pausal context is the less favouring position for reduction processes in stops: in all the speakers, they are realised as voiceless stops, although some of them without burst (22 % for I., 15 % for R. and 16 % for P. L.).

Similarly, [s] preceding a stop doesn't allow reduction processes to be applied in any of the speakers, and as far as [r] plus stop is concerned, the maintenance is the common result (54 % for I., 72 % for R., 100 % for J. C. and P. L.).

With respect to nasal contexts, labial stops show a strong tendency to the preservation (59 %, 68 %, 100 %, 80 % for I., R., J. C. and P. L. respectively), but there are some cases of voicing (15 % and 19 % for I. and R.). On the other hand, velar and dental stops become voiced for R. (42 % of velar occurrences and 45 % of dental ones) and I. (12 % of /k/ cases and 16 % of /d/ ones).

Finally, dental stop after a lateral shows a tendency to voicing, although it seems to be a personal characteristic of the speaker R. (33 %). In the cases of labial and velar, the only result is the plosive.

3.1.2. Voiced stops

The distribution of voiced stops /b, d, g/ in Spanish is complementary to that of the approximants [β], [ð] and [ɣ]. Voiced stops appear after a pause or a nasal, and after [l] only for /d/. In the rest of cases, /b/, /d/, /g/ are realised as approximants.

However, approximant realisations after nasals are frequently found in analysed items for /d/ and /g/ in speakers R. and I. In addition, deletion of velar and dental stop appears for all the speakers in a quite high percentage (see Table II).

As far as [l] plus dental stop is concerned, cases of preservation as well as examples of approximants are found (Table II).

		DIALOGUE		MONOLOGUE	
		R.	I.	J. C.	P. L.
/m+b/	stop	90.0	75.0	100.0	100.0
	approximant	10.0			
	deletion		25.0		
/n+d/	stop	44.7	50.0	61.8	71.7
	approximant	20.6	13.0		
	deletion	34.4	35.0	38.2	28.2
/n+g/	stop	15.0	52.0	63.6	68.7
	approximant	25.0	5.8		
	deletion	60.0	41.0	36.3	31.2
/l+d/	stop	66.6	14.0	71.4	70.0
	approximant	22.2	85.7	14.3	30.0
	deletion	11.1		14.3	

Table II. Frequency of occurrence (in %) of the phonetic results of /b, d, g/.

3.2. Approximants

It has been noted above that voiced stops [b, d, g] and approximants [β, ð, ɣ] are in complementary distribution. Concerning phonetic reduction processes, if voiced stops become frequently approximants, approximants are omitted in a high percentage of cases, although deletion seems to be strongly dependent on the speaker.

Table III shows the results for approximants in intervocalic context: the consonant with more deletions is the dental one, followed by velar and labial for speakers R. and I., but by labial and velar for the other speakers.

Approximants preceded by [s], however, tend to become stops (28 % for I., 33 % for R., 11 % for J. C.) or fricatives (33 % for R. and J. C.). Similarly, velar and labial approximants when preceded by a lateral show a stop realisation (28 % for I. and 31 % for R.).

		DIALOGUE		MONOLOGUE	
		R.	I.	J. C.	P. L.
[β]	Approximant	91.7	89.5	78.0	83.9
	Deletion	8.2	10.4	22.0	16.0
[ð]	Approximant	72.7	67.5	74.0	82.4
	Deletion	27.2	31.9	26.0	17.5
[ʁ]	Approximant	87.7	81.5	97.4	93.1
	Deletion	12.2	18.4	2.6	6.8

Table III. Frequency of occurrence (in %) of the acoustic results for the approximants in intervocalic context.

3.3. Fricatives

The consonantic system of Spanish has four fricatives: /f/, /θ/, /s/ and /x/. When they are followed by voiced consonants, only the alveolar fricative becomes voiced.

Voicing and weakening are the two processes shown by these consonants. Weakening cases have been established when the intensity of energy is low or even disappears. The degree of this intensity has been considered depending on the intrinsic energy values of each consonant.

In an intervocalic environment, the voicing process is found for all fricatives, except for [x], in every analysed speaker. However, there is a decrease of the occurrence of voiced cases from the [s] to [f]. This fact can be associated with an advanced point of the articulation.

		DIALOGUE		MONOLOGUE	
		R.	I.	J. C.	P. L.
/f/	fricative	56.2	36.6	74.9	75.9
	weakening	40.6	56.6	24.9	24.1
	voicing	3.1	6.6		
/θ/	fricative	49.9	57.1	65.0	75.0
	weakening	38.1	40.4	32.0	22.0
	voicing	11.8	2.3	3.0	3.0
/s/	fricative	73.5	68.1	84.3	84.5
	weakening	6.4	16.5	0.9	0.5
	voicing	20.0	14.4	14.7	15.0
/x/	fricative	88.8	54.9	84.5	85.2
	weakening	11.1	45.0	15.4	14.7
	voicing				

Table IV. Frequency of occurrence (in %) of the manifestations of the fricatives in intervocalic environment.

In relation to the weakening process, a gradation in percentages is also found: [f] is characterised by the greatest loss of energy and [s] by the smallest one. There is, therefore, an interaction between voicing and weakening processes for fricatives (see Table IV).

Finally, the consonantic context seems to preserve the fricatives. Table V shows pooled results for fricatives preceded by voiced consonants. Cases of fricatives after voiceless consonants have not been presented due to the small number of available items.

		DIALOGUE		MONOLOGUE	
		R.	I.	J. C.	P. L.
fricative		72.9	62.5	76.7	84.4
weakening		22.0	37.5	17.8	9.6
voicing		5.1		5.5	6.0

Table V. Frequency of occurrence (in %) of the acoustic manifestation of fricatives preceded by voiced consonants.

3.4. Trills / Flaps

In the consonantic system of Spanish, there are two different phonemes /r/ and /ɾ/ which are only phonologically contrastive between vowels. Trills also appear after [n], [l] or pause while flaps appear before consonants.

In intervocalic environment, trills are manifested as a trill, flap, approximant or fricative (see Table VI). For the speakers J. C., P. L. and R., the trill is found with a higher percentage although for R., approximant, flap and fricative results are shown in many cases. On the other hand, the majority of realisations for I. are approximants; it can be a personal articulatory habit of the speaker.

Trills preceded by consonants or pauses display as a trill in all speakers (100 % in all cases).

Flaps, approximants and deletions are the three acoustic manifestations for the flap. In intervocalic context, flaps and approximants are characteristic of the speakers J. C. and P. L. whereas approximants and deletions are peculiar to R. and I. (see table VI).

		DIALOGUE		MONOLOGUE	
		R.	I.	J. C.	P. L.
	trill	44.4	30.7	81.0	59.2
	flap	29.6	11.5	10.3	32.6
/r/	approximant	11.1	57.6	6.9	6.1
	fricative	14.8		1.7	2.0
/ɾ/	flap	32.0	6.0	53.5	43.0
	approximant	57.0	84.1	29.6	54.4
	deletion	11.0	9.7		3.4

Table VI. Frequency of occurrence (in %) of the manifestations of the trills/ flaps in intervocalic context.

Deletion cases increase when flaps are followed by consonants for R. (15.7 % for voiceless consonants and 44.1 % for

voiced ones) and I. (15.3 % for voiceless consonants and 14.2 % for voiced ones). There isn't any case of deletion for the speakers J. C. and P. L. when the following consonant is voiced.

3.5. Affricates

Phonologically, Spanish has only a voiceless affricate /tʃ/. Voiced affricate [dʒ] can appear after a pause and after /l, n/ as a contextual variant of /ʒ/.

In the analysed data, examples of voicing of the silent period are found for the speaker R.; however, voicing doesn't affect the friction noise. There are as well some desaffrication cases for R., J. C. and P. L.

Nevertheless, the most frequent weakening in intervocalic context is the loss of burst for all speakers, as it can be observed in Table VII.

	DIALOGUE		MONOLOGUE	
	R.	I.	J. C.	P. L.
affricate	55.5	34.3	52.4	35.5
loss of burst		65.6	46.1	64.5
voicing	38.8			
desaffrication	5.5		1.5	3.2

Table VII. Frequency of occurrence (in %) of the manifestations of the affricate in intervocalic context.

Available cases in consonantic environment are very few and they only appear in the recordings of the speakers J. C. and P. L., but they don't show any reduction.

4. DISCUSSION AND CONCLUSIONS

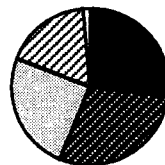
The study of phonetic processes bears light on the classification of speaking styles. On the one hand, some processes are common for all the analysed speakers: weakening in the fricatives or the behaviour of /r/ like an approximant. These processes can be considered as peculiar of the conversational speech in front of laboratory speech. On the other hand, the behaviour of voicing in voiceless stops, deletion and weakening in approximants and flaps has shown that it is possible to differentiate between two substyles depending on a gradation of spontaneity. Figure 1 shows results from acoustic analysis for voiceless stops in the two groups considered: it can be observed that the degree of maintenance in group B is higher than in A. This fact corresponds to the difference between monologue and dialogue cases.

In summary, the study of low-level phonetic processes not only can differentiate between laboratory speech and casual speech, but their frequency of occurrence can characterise the degree of casualness.

Referring to consonants, it can be said that in spontaneous speech any consonant is affected by some sort of weakening process. The reduction is manifested in different ways depending on the intrinsic characteristics of the consonants:

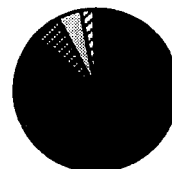
fricatives show weakening in the form of a loss of energy, whereas a gradation voiceless stop > voiced stop > approximant > deletion is found in stops.

GROUP A: R. and I.



voiceless stop (27.3%)
unrdld vlss stop (29.1%)
voiced stop (24%)
approximant (17.8%)
deletion (1.8%)

GROUP B: J.C. and P.L.



voiceless stop (86.6%)
unrdld vlss stop (5.7%)
voiced stop (4.8%)
approximant (2.8%)
deletion (0.1%)

Figure 1. Percentages of voiceless stops according to a gradation of spontaneity. Group A corresponds to dialogue and group B to monologue.

With respect to context, the intervocalic one favours all kind of reduction processes while in most of occasions, postpausal and postconsonantal contexts block them.

According to Kohler [2], then, a large range of signal variability has been found in the analysed corpora as a continuum of articulatory reduction although speakers' articulatory habits shouldn't be denied.

Finally, it has been attested that speech environments exhibit varying degrees of spontaneity depending on the communicative relation established between the speakers (Lindblom [3]).

5. FURTHER RESEARCH

Further analysis referring to nasals and laterals is needed in order to complete the study of the Spanish consonantal system. In addition, research on vowels and diphthongs is still required.

On the other hand, the loss of syllabic sequences should be checked in order to get phonetic information about the syllabification process in spontaneous speech.

6. REFERENCES

- [1] HARRIS, J.W., *Spanish Phonology*, MIT Press, Cambridge, 1969.
- [2] KOHLER, K. "The Phonetics/ Phonology issue in the Study of Articulatory Reduction", *Phonetica*, 48 (2-4): 180- 192, 1991.
- [3] LINDBLOM, B. "Explaining Phonetic Variation: A Sketch of the H and H Theory", W. J. HARDCASTLE- A. MARCHAL. *Speech production and Speech Modelling*, Kluwer Academic Publishers, Dordrecht, 1990, pp. 403-439.
- [4] NAVARRO TOMÁS, T. *Manual de pronunciación española*, RFE, Madrid, 1918.

为了完成对西班牙辅音系统的研究，还需要对鼻部和边音进行进一步的分析。此外，对元音和双元音的研究仍有必要。

另一方面，为了获得自发语音中音节化过程的语音信息，必须检查音节序列的丢失情况。