A STUDY OF [r] AND [ɾ] IN SPONTANEOUS SPEECH

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ABSTRACT

This paper describes the acoustic features of the Spanish [ɾ] and [r] both in spontaneous and in laboratory speech. The results discussed below show that a shorter duration and the reduction of the ratio values of the differences between the second formant and the following vowel are of prime importance in spontaneous speech. However there is a close relation between the second formant of the consonant and that of the adjacent vowels both in spontaneous and in laboratory speech.

1. INTRODUCTION

One of the most common approaches in studying [ɾ] and [r] has been the analysis of their duration, and therefore it is wellknown the description of the several phases (closed and open) in [r] (*e.g.* FANT [1]). Some works have also noted the importance of the vocalic context in formant frequencies in Spanish (QUILIS [2]).This paper suggests some relevant differences in duration and spectral structure for both [ɾ] and [r] in two speaking styles.

2. EXPERIMENTAL PROCEDURE

Data from spontaneous speech have been obtained from an hour recording of speech obtained by asking the subject -a male Spanish speaker- about the city where he comes from, his family, his work, the militar service, etc.

These *data* have been compared with those obtained by studying [ɾ] and [r] in laboratory speech, that is, embeded in carrier sentences which were read at a normal speech rate by the same subject.

The registration was made in a sound proof room at the Phonetics Laboratory at the Universitat Autònoma de Barcelona, using a Revox A/77 tape recorder and a Shure 515 Sb Unidyne microphome.

The *corpus* was then low-pass filtered, digitized at a sample rate of 10 Khz, and stored. It was analysed by means of broadband spectrograms using a Mac Speech Lab II™ programme.

Both [ɾ] and [r] have been studied in intervocalic contexts, either in stressed and unstressed syllables.

A whole of 300 items -uttered in labotatory speech- and 445 items -coming from natural speech- have been segmented and measured. A simple statistic analysis have been performed to extract mean values of the consonant duration, the four first formant frequencies of these consonant, and the four first formant frequencies of the C-V transition starting point.

Intensity values are not studied in this paper. However, it should beinteresting to havealso into account the strong decrease in the sound pressure level of the consonant in futher research, as it has been pointed out by CHAFCOULOFF [3].

3. RESULTS

3. 1. Duration

It has been pointed out that one of the most important differences between continuous speech and laboratory speech is duration. There is indeed a shortening phenomenon which is closely related to the fact that the speaking rate is usually much faster in continuous speech. Spanish [ɾ] and [r] are shorter in spontaneous speech, as is shown in Table 1.

TABLE 1: Mean duration values (in miliseconds). Comparison between laboratory and spontaneous speech.

	Laboratory Speech		Continuous Speech
[ ]	31.6		27.1
[r]	Total		45.31
	68.68		
	3 stages	5 stages	
	58.65	79.43	

Some remarks can be made about [r]. Its duration depends on the number of its closed and open stages. In speech laboratory [r] can be uttered with three or five different phases, and it affects the total duration as it is pointed at Figure 1. The results obtained by means of a t-statistic test prove that there are two different populations indeed, so that the degree of significance is 0.000.

A statistical study of the several phases for each type of [r] shows that differences among them are not significative as for duration.

The mean values of [r] duration in laboratory speech, taking into account the two kind of populations are those in Table 2.

However, these three or five stages do not appear in spontaneous speech. There are at most two different phases, a closed phase -the first- and an open one, and it is interesting to mark that the open stage presents a concentration of energy in the upper zones of frequency. A t-statistic test suggest us that each phase lasts aproximately the half of the whole duration. The mean values are: 24.5 ms. for the closed phase and 22.18 ms. for the open one.

On the other hand, as for [ɾ], there is a significative difference in miliseconds between spontaneous speech and laboratory speech. The mean values at Table 1 show the same differences observed at Figure 2 and Figure 3.

Both [ɾ] and [r] are shorter in continuous speech, although [r] is always the shortest one.

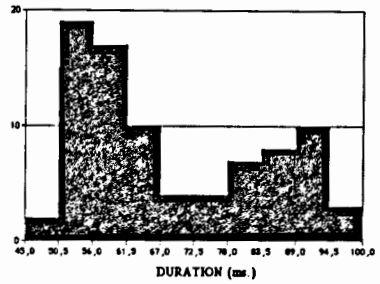

FIGURE 1: Histogram. Mean duration values for [r] in laboratory speech.

TABLE 2: Mean duration values (in miliseconds) for [r] in laboratory speech.

	closed s.		open s.		closed s.
3 stages	19.3 s.d.: 3.5		18.2 s.d.: 2.2		18.1 s.d.: 3.7
	cl.s.	op.s.	cl.s.	op.s.	cl.s.
5 stages	16.9 s.d.: 3.1	17.3 s.d.:2.5	18 s.d.:2.5	17.1 s.d.:2.4	16.8 s.d.:2.5

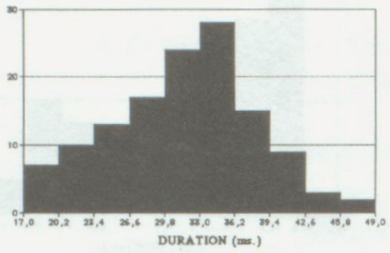

FIGURE 2: Histogram. Mean duration values for [ɛ] in laboratory speech.

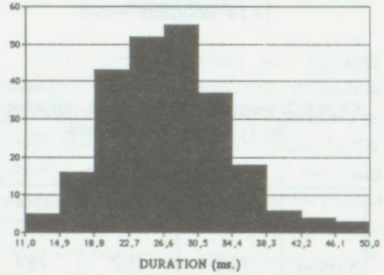

FIGURE 3: Histogram. Mean duration values for [ɛ] in spontaneous speech.

3. 2. Formant frequencies

The mean frequency values for the four first formants are those at Tables 3 and4. However, note that, as an hour of spontaneous speech reports us much more cases of A-[r]-E than of U-[r]-U, for instance, these values have been obtained by homogenizing the number of cases with each vocalic context in spontaneous speech. Otherwise, the values are not able to be compared with those obtained in laboratory speech.

TABLE 3: Mean frequency values for [ɛ] in laboratory and spontaneous speech. (Hz.)

	Laboratory speech	Spontaneous speech
F4	3452.33	3409.11
F3	2304.06	2287.24
F2	1384.85	1354.29
F1	367.75	405.93

TABLE 4: Mean frequency values for [r] in laboratory and spontaneous speech. (Hz.)

	Laboratory speech	Spontaneous speech
F4	3397.05	3361.74
F3	2067.2	2025.49
F2	1129.48	1201.34
F1	434.4	443.13

The differences between laboratory and continuous speech in the steady state of the consonant do not seem to be very large. Furthermore, the consonant shows the same behaviour in both cases: the first and the second formant depend on the vocalic context, as it is shown in tables 5 and 6.

TABLE 5: Mean frequency values for [r] in laboratory speech (LS) and spontaneous speech (SS). Influence of the vocalic context on F1 and F2. (Hz).

F1	i/u	e/o	a
LS	313.48	383.31	456.83
SS	294.8	403	469.18
F2	o/u	a	e/i
LS	1023.6	1210.66	1703.84
SS	1038.86	1241.9	1600.4

TABLE 6: Mean frequency values for [r] in laboratory speech (LS) and spontaneous speech (SS). Influence of the vovalic context on F1 and F2. (Hz).

F1	i/u	e/o	a
LS	360.91	446.21	470.93
SS	no cases enough	428.15	496.66
F2	o/u	a	e/i
LS	1091.78	1089.93	1271
SS	no cases enough	1240.77	1396.27

By the other hand, some differences between spontaneous and laboratory speech can be stated as for frequencies.

The relationship between the second formant steady state of the consonant and the transition starting point depends on the following vowel, but differs because of the speech style. This relationship would be even more evident if we taked into account the steady state of the vowel. Note that the difference between the two points is higher in palatal than in velar contexts. But, anyway, differences are always higher in laboratory speech than in spontaneous speech. This fact can be expressed by means of percentages, as is shown in Table 7.

TABLE 7: Percentages. Difference between the second formant frequencies of the steady state of the vowel andthe following transition starting point. Comparison between spontaneous and laboratory speech.

	[ɛ]		[r]	
	e/i	o/u	e/i	o/u
LABORATORY SPEECH	10.7 %	2.9 %	7.2 %	1.9 %
SPONTANEOUS SPEECH	5.7 %	1.6 %	2.5 %	no cases enough

3.3. Spectral distribution

In fact, the results suggest that spontaneous speech favour the concentration of energy in the upper zones of frequency. About a third of the studied cases of [ɛ] in spontaneous speech show aperiodic energy in the higher frequencies, and about the ninety per cent of cases of [r] are periodic frictions. The fourth formant is the most intense in many cases. However, both [ɛ] and [r] are completely periodic in laboratory speech.

Figures 4 and 5 show some of the spectral differences observed between continuous and laboratory speech for [ɛ] and[r].

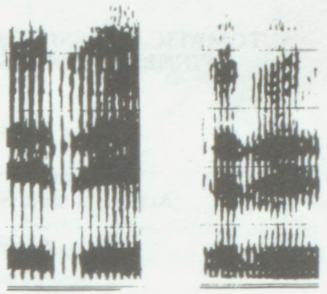

FIGURE 4: [ɛ] in laboratory speech and in continuous speech. Context: [e ɛ 'e].

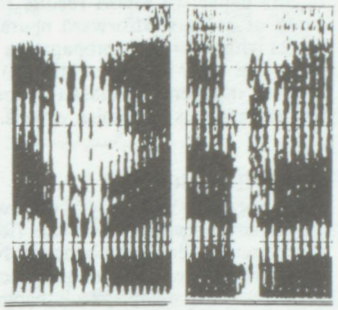

FIGURE 5: [r] in laboratory speech and in continuous speech. Context: [e r 'e].

4. CONCLUSION

Speaking style differences are found on duration, which is shorter in spontaneous speech, and on the reduction of the ratio values of the frequency differences between the steady state of the second formant of the consonant and that of thenext vowel. Further research should pay attention to intensity levels of [ɛ] and [r] in Spanish and to their spectral distribution in spontaneous speech.

5. REFERENCES

[1] FANT, G. (1960), *Acoustic theory of speech production*, The Hague: Mouton & Co.: 162-168.
[2] QUILIS, A. (1981), *Fonética acústica de la lengua española*, Madrid: Gredos: 290-306.
[3] CHAFCOULOFF, M. (1979), "Les propiétés acoustiques de [j, y, w, l, r] en français", *Travaux de l'Institut de Phonetique d'Aix*, vol. 6: 10-24.