

# Proceedings of the 15th International Congress of Phonetic Sciences

Barcelona 3-9 August 2003

Volume 1 of 3



**UAB**

Universitat Autònoma  
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# Proceedings of the 15<sup>th</sup> International Congress of Phonetic Sciences



Barcelona  
3-9 August 2003

Volume 1 of 3

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Edited by: M.J. Solé, D. Recasens & J. Romero

## PAST CONGRESSES

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1935	London
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1964	Münster
1967	Prague
1971	Montréal
1975	Leeds
1979	Copenhagen
1983	Utrecht
1987	Tallinn
1991	Aix-en-Provence
1995	Stockholm
1999	San Francisco

ISBN: 1-876346-49-3 (Book Set of 3 Volumes)  
ISBN: 1-876346-48-5 (CDROM)

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Published by: Causal Productions Pty Ltd ([info@causal.on.net](mailto:info@causal.on.net))

Cover design by: Causal Productions  
Cover photographs courtesy of: J. Romero & M.J. Solé  
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## NOTE FROM THE CHAIRS

We welcome you to the 15th International Congress of Phonetic Sciences (15<sup>th</sup> ICPhS) in Barcelona, Spain, August 3 -9, 2003 – the first ICPhS in the third millennium. The Barcelona Congress, which is officially sponsored for the first time by the International Phonetic Association, provides an interdisciplinary forum for the exchange of ideas and basic research in the phonetic sciences. Since the first meeting in Amsterdam in 1932, the ICPhS has become the most important meeting in the phonetic sciences.

The congress brings together international experts in phonetics within the areas of linguistics, language acquisition, communication disorders, psychology and speech technology. The congress addresses how phonetic theory, engineering and linguistics can contribute to the solution of real-world problems in speech processing and transmission, voice identification, man-machine communication, speech deficits and language teaching. It also offers the opportunity to further our knowledge about instruments and techniques originally built for other purposes (e.g., MRI, ultrasound, etc) that are now finding a new and unexpected use in the understanding of how human speech works.

More than 1200 contributions were submitted to the Barcelona Congress. An international committee of reviewers accepted approximately 800 papers that were organized into coherent oral and poster sessions that will certainly be of interest to experts in the different areas of the phonetic sciences. We also encouraged the organization of 22 symposia coordinated by renowned experts who were in charge of inviting other specialists to participate in their symposia. Due to the large number of symposia and contributed papers, the Congress will feature 5 parallel sessions scheduled for 5 full days. The scientific program includes 5 plenary lectures, 22 symposia and about 73 oral and poster sessions with around 800 papers, which will appear in the Congress Proceedings in book and CD-ROM formats. There are also exhibitions, association and satellite meetings, a banquet, day-trip excursions, receptions and social events. The Catalan and Spanish phonetic sciences community is proud to host this large and high-quality scientific event.

The organization and attendance of the 15<sup>th</sup> ICPhS has been through some challenges due to international events – September 11<sup>th</sup>, the strikes on Afghanistan and later on Iraq, the SARS scare, etc. Despite all, the 15<sup>th</sup> ICPhS will bring the scientific community together to share knowledge, methods, aims and our desire for peace.

We hope these proceedings will be a valuable resource for your future research, as they sample the most current research in the phonetic sciences. Enjoy.

Daniel Recasens

Chair

Maria-Josep Solé

Co-chair

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## STATISTICS FOR THE ICPHS 2003 PROCEEDINGS

<i>Sessions</i>		<i>Contributions</i>
5	Plenaries and Discussion papers	10
22	Symposia	85
55	Oral Sessions	337
18	Poster Sessions	427
<b>100</b>	<b>Total</b>	<b>859</b>

### NUMBER OF CONTRIBUTIONS PER COUNTRY (Oral and poster sessions)

This list is taken from our database and represents the first author wherever possible.

158	USA	4	Norway
81	France	4	Taiwan
73	Germany	3	Belgium
71	UK	3	Estonia
46	Japan	3	Tunisia
45	Spain	2	Egypt
41	Sweden	2	Hungary
31	Netherlands	2	Israel
25	Canada	2	Morocco
19	Russia	2	Northern Ireland
17	Italy	2	Saudi Arabia
14	Finland	2	South Korea
12	Australia	2	Switzerland
12	Brazil	2	Thailand
12	China	2	Venezuela
7	Ireland	1	Belarus
7	North Korea	1	Cuba
7	Poland	1	India
6	Denmark	1	Jordan
6	Portugal	1	Lebanon
5	Austria	1	Malta
5	Hong Kong	1	Mexico
5	Slovenia	1	New Zealand
4	Croatia	1	Nigeria
4	Czech Republic	1	Singapore
4	Greece		

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# A Contrastive Study of Voiced Alveolo-Palatal Affricates in the Catalan of Lleida and Barcelona

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## ABSTRACT

The realization of the voiced alveolo-palatal affricate consonant in Catalan presents a lot of variation as far as the voicing and duration of both plosive and fricative segments are concerned. This variation is related to the different geographical varieties of Catalan and it ranges from voiced to voiceless realizations with their corresponding intermediate stages. A number of studies have attempted to find out whether the segment that devoices first is the plosive or the fricative element. The present study aims to characterize and contrast various realizations of voiced alveolo-palatal affricates in the Catalan of Lleida and Barcelona in a sample of words containing these consonants (voiced and voiceless) in intervocalic position. The results show that the phenomenon of devoicing first begins in the fricative segment in the two varieties of present-day Catalan, although it is more widespread in the Catalan of Barcelona.

## 1. INTRODUCTION

Catalan is a Romance language spoken by some seven million inhabitants of Spain, distributed over Catalonia, Valencia, part of Aragon and the Balearic Islands. It is also spoken in Andorra, Rousillon and L'Alguer. Catalan has two major dialectal regions: the Eastern diasystem (including the Eastern dialects: Central Catalan, Balearic, Roussillonese and Alguerese) and the Western diasystem (containing the Western dialects and Valencian). Their two dialectal diasystems differ as to both their unstressed and stressed vowel systems. In non-stressed position, the Eastern dialects have three vowels and the Western ones, five.

As for consonant sounds, a number of studies on the acoustic nature of voiced alveolo-palatal affricates have shown in both dialects the existence of an important variability in the duration of plosive and fricative segments, as well as in the partial devoicing of this compound sound. In this respect, a few dialectal and acoustic studies on the Catalan language have proven the presence of a process of devoicing of affricate sounds, both in Eastern [2] and Western regions [1]. On examining which segment – plosive or fricative – devoices in the first place, there are two opposing views. On the one hand, there is the view stating that the plosive element devoices first [4]. On the other hand, there is the view that considers the fricative sound to devoice first [5,1 and 3].

## 2. METHOD

The consonants studied in this paper are the voiceless and voiced alveolo-palatal affricates: [tʃ] and [dʒ], respectively. The affricate sounds in question appeared in two-, three-, and four-syllable words, whose stress was either on the syllable immediately preceding the affricate or on the syllable that contained the affricate. The affricates were realized in intervocalic position: 1) for the Catalan of Barcelona (henceforth CBCN), the vowel contexts were: [íCə, áCə, úCə, iCá, əCá, uCá]; 2) and for the Catalan of Lleida (CLL): [íCe, áCe, úCe, iCá, aCá, uCá]. The words in the study differed as to their frequency of use: high frequency words (HF) or low frequency words (LF).

The words were elicited by reading aloud a list of sentences in which they were included. In order to deviate the subjects' attention from the purpose of the study, these meaningful, declarative sentences were interspersed with other sentences that did not contain words for analysis. The words of interest appeared in mid-sentence position to avoid the voice inflexions that result from the onset and prosodic nucleus. All sentences were elicited three times. Twenty university students between the ages of 18 and 35 participated in the study. There were 5 women and 5 men from CBCN, and another 5 women and 5 men from CLL. The statistical analysis carried out was a One-Way ANOVA on each of the following parameters: duration and voicing of occlusion and frication, and perceptual relation between voicing duration in the plosive segment and total stop duration.

## 3. OBJECTIVE

The aim of this contrastive study was to show acoustically that voiced affricates in both CBCN and CLL present a noticeable process of devoicing that begins in the fricative segment. Thus, the objective was to find out whether the above-mentioned devoicing process is enhanced by one or the other dialects examined, by the subjects' gender, by the number of syllables in the word containing the consonant group, by the position of stress in the word, by the surrounding vowels preceding and following the consonant in question, and by the word use frequency.

## 4. RESULTS

The results obtained are classified as follows, according to the variables of study.

#### 4.1. EFFECTS OF DIALECT

To test for the effect of the variable of dialect, the resulting data matrix was split according to the affricate (voiceless-voiced) and the subjects' gender (male-female). The One-Way ANOVA performed showed that the differences between the two dialects were significant for all the factors considered ( $p = 0.000$ ). First, both in male and female speech samples, stop duration and voicing duration of plosives (in the case of voiced affricates) were longer in speakers of CLL than in those of CBCN. More precisely, the voicing percentages for the plosive element of CLL were 85% and 89% in male and female speakers, respectively. And in the case of CBCN, the voicing percentages were 76% for male subjects and 73% for female subjects (see Figure 1).

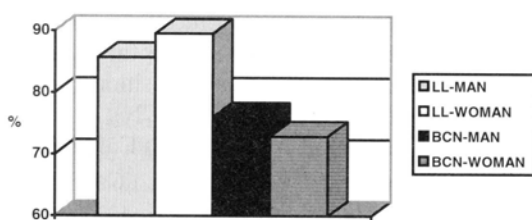


Figure 1. Voicing percentages of the plosive element in voiced affricate

By contrast, the fricative segment was longer in duration in the dialect of BCN. It should be noted that voicing in this segment was barely present, especially in female speakers of both dialects (although it was more noticeable in female speakers of CBCN, whose fricative productions were hardly ever voiced).

Finally, stop duration was found to be always longer than fricative duration.

#### 4.2. EFFECTS OF GENDER

In this case, the variable of gender was looked at for each affricate and dialect. Nearly all the differences observed between male and female speakers' productions were statistically significant ( $p < 0.05$ ) in all the variables studied. Only two comparisons yielded nonsignificant results: stop voicing in the subjects from BCN ( $F=0.862$ ,  $p=0.353$ ), and the relation between stop duration and its voicing in CBCN ( $F=3.084$ ,  $p=0.079$ ). On the whole, the duration of the plosive segment was longer in women's productions, as well as the voicing duration in the plosive segment, if applicable. On the contrary, fricative duration was longer in men's productions (except for fricative voicing in the dialect of LL).

#### 4.3. EFFECTS OF AFFRICATE

All variables resulted in statistically significant differences ( $p = 0.000$ ) between the duration of voiceless and voiced realizations, both in the plosive and fricative segments of the two dialects. The comparison between voicing duration in the plosive and fricative segments was also significant, for the duration of voiceless realizations is always zero.

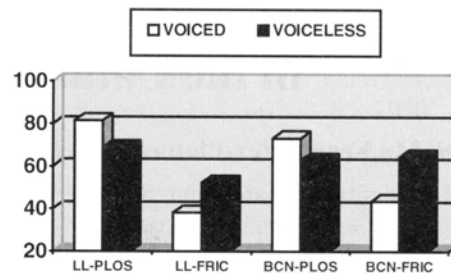


Figure 2. Duration of the plosive and fricative elements of affricates

As seen in Figure 2, stop duration was longer in voiced affricates, whereas fricative duration was longer in voiceless affricates. In addition, plosive segments were longer in CLL than in CBCN.

#### 4.4. EFFECTS OF NUMBER OF SYLLABLES

In this case, the effect of the variable of syllable was examined for each consonant group, gender, and dialect (based on its significance – see former sections).

In voiceless articulations, significant differences in stop duration were found in all circumstances (i.e., according to gender and dialect) ( $p < 0.05$ ); as well as significant differences in the duration of the fricative segment in female speakers of CLL ( $F=4.177$ ,  $p=0.016$ ). Scheffé post-hoc tests showed that, in the case of male speakers of CLL, the significant differences were located between two- and three-syllable words ( $p=0.07$ ). That is, stop duration was significantly longer in two-syllable words than in three-syllable words ( $\bar{x}=69.01$  ms,  $sd=16.91$ , as opposed to  $\bar{x}=62.97$  ms,  $sd=15.15$ ). As for male speakers of CBCN, the differences were found between two- and three-syllable words ( $p = 0.000$ ), and between three- and four-syllable words ( $p = 0.032$ ). For those speakers, the duration of the plosive segment followed the sequence  $2 > 4 > 3$  syllables:  $\bar{x}=61.84$  ms,  $sd=14.98$ ;  $\bar{x}=58.11$  ms,  $sd=15.42$ ;  $\bar{x}=53.96$  ms,  $sd=10.63$ . Female speakers of CBCN's productions presented statistically significant differences between two- and three-syllable words ( $p=0.000$ ), being the plosives of two-syllable words longer in duration ( $\bar{x}=71.25$  ms,  $sd=16.75$ , as opposed to  $\bar{x}=63.73$  ms,  $sd=14.55$ ). Finally, female speakers of CLL differed significantly in the duration of the plosive and fricative elements between two- and three-syllable words ( $p=0.000$  and  $p=0.016$ , respectively). In both cases, the duration of two-syllable words was longer than that of three-syllable words.

In voiced realizations, significant differences ( $p < 0.05$ ) were found for stop duration in the two dialects for both male and female speakers. Significant differences were also found in voicing duration in the plosive, except for female speakers of CLL; and in voicing duration in the fricative segment for female speakers of CLL. Scheffé post-hoc comparisons showed that the significant differences were located between four- and three-syllable words, and between four- and two-syllable words (except

for CBCN female speakers), as far as stop duration was concerned. In general terms, the more syllables a word contained, the longer the duration of the plosive segment. As for voicing duration in absolute values, significant differences were found between four- and two-syllable words, in addition to two- and three-syllable words in CBCN female productions. As in the evaluation of the plosive segment, the larger the number of syllables in a word, the longer voicing duration was. And in CLL female speakers, fricative duration resulted in significant differences between four- and two-syllable words. Similarly, the values obtained followed the general trend, i.e., the larger the number of syllables in a word, the longer the segment duration.

As for the percentage relation between voicing duration in the plosive and its total duration, this important parameter only yielded significant results in CBCN male subjects between two- and three-syllable words ( $p=0.033$ ) ( $\bar{x}=70.94$  ms,  $sd=36.18$ ; and  $\bar{x}=79.83$  ms,  $sd=25.53$ , respectively), and in CBCN female speakers also between two- and three-syllable words ( $p=0.015$ ) and between two- and four-syllable words ( $p=0.047$ ) ( $\bar{x}=69.00$  ms,  $sd=24.47$ ;  $\bar{x}=76.02$  ms,  $sd=20.81$ ;  $\bar{x}=72.94$  ms,  $sd=22.38$ ). That is, the voicing percentage in the plosive showed the sequence  $3 > 4 > 2$  syllable words (see Figure 3).

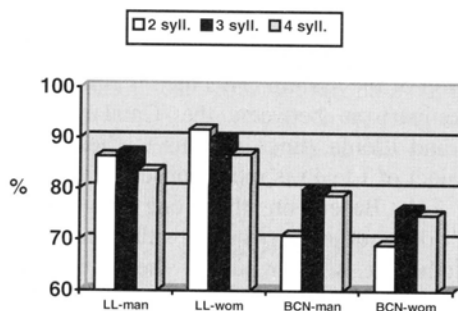


Figure 3. Voicing percentages of the plosive element in voiced affricates.

As seen in the figure above, voicing values of the plosive were higher in CLL than in CBCN. In other words, the process of devoicing was more pronounced in CBCN.

#### 4.5. EFFECTS OF WORD USE FREQUENCY

To study this variable, the same factors as in Section 4.4 were considered. On the whole, the results obtained by means of a One-Way ANOVA showed that there existed significant differences ( $p < 0.05$ ) in the duration of plosive segments and their voicing duration (in voiced realizations) –but not in fricative segments– according to whether it was a HF word or a LF word. The few exceptions to this tendency were the following: fricative duration in CLL male subjects both in voiced ( $F=10.818$ ,  $p=0.001$ ), and voiceless ( $F=4.918$ ,  $p=0.027$ ).

Overall, a low frequency word in the language enhanced larger duration of segments.

The percentage relation between voicing duration in plosives of voiced affricates and total duration of the segment was significantly affected by this variable in CLL

speakers and in CBCN male subjects. On the contrary, CBCN female subjects –the group with higher devoicing values– was not affected by this variable (see Figure 4):

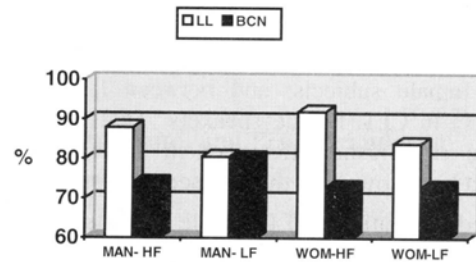


Figure 4. Voicing percentages in the plosive element of voiced affricates in relation to the usage frequency of words.

#### 4.6. EFFECTS OF STRESS

To study this variable, the same factors as in Section 4.4 were considered.

The uniform results found in the study of the other variables did not take place in this variable. In voiceless articulations, the fact that the affricate appeared either in a stressed or unstressed syllable was not relevant in the CLL male subjects' productions. This fact was relevant in stop duration only as produced by CLL female and CBCN male subjects ( $F=6.031$ ,  $p=0.014$  and  $F=4.684$ ,  $p=0.031$ , respectively). Conversely, in CBCN female speakers the significant difference was located in the duration of the fricative ( $F=5.972$ ,  $p=0.015$ ).

In voiced articulations, the results for CLL male speakers and CBCN female speakers coincided in that the factor of stress yielded significant differences ( $p < 0.05$ ) in the following variables: stop duration, obstruent voicing, and fricative duration. CLL female subjects' samples only presented significant results in the two parameters that referred to the plosive segment, while CBCN male speakers obtained significant results in fricative duration solely.

In general, the realizations studied had a longer duration when they appeared in stressed syllables, in particular plosive segments. In no case did the variable relating voicing duration in the plosive with total stop duration present significant differences as to the position of stress in the word.

#### 4.7. EFFECTS OF VOWEL CONTEXT

To study this variable the same factors as in Section 4.4. were considered. In voiceless realizations, the fact that the affricate appeared in one or another vowel context had a significant effect ( $p < 0.05$ ) on both stop and fricative duration in each dialect in both sexes. Scheffé post-hoc comparisons revealed that the difference in segment duration was between [aCa] and [iCa], and between [aCa] and [uCa]<sup>1</sup> ( $p=0.000$  in all cases). The plosive in the context [aCa] was noticeably longer than those plosives

<sup>1</sup> Vowels that appear as [a] are, in fact, realized as [a] or [ə] in CBCN and as [a] and [ɛ] in CLL, depending on whether they are in stressed or unstressed syllable-positions, respectively.

realized in other vowel contexts. As for fricative duration, the segment elicited in the context [aCa] was also longer. Other significant differences were found between [aCa] and [uCa] in male speakers of both dialects ( $p=0.003$  in CLL;  $p=0.018$  in CBCN); between [aCa] and [uCa] ( $p=0.036$ ), and between [aCa] and [iCa] ( $p=0.001$ ) in CBCN female subjects; and between [aCa] and [iCa] ( $p=0.021$ ) in CLL female speakers. That is to say, there were no significant differences in vowel contexts that involved high vowels as the stressed or unstressed vowels.

In voiced realizations, CLL female subjects' did not differ significantly in any comparison. In other words, the effect of the vowel context was not relevant in their productions. However, CBCN female speakers presented significant differences in stop voicing duration between [aCa] and [uCa] ( $p=0.042$ ), and in the relation between such voicing and total duration of the segment in the same pairwise comparison ( $p=0.028$ ). Male speakers of both dialects differed significantly in the relation of voicing with total duration of the plosive segment between [iCa] and [aCa] ( $p=0.017$ ) in CLL, and between [uCa] and [aCa] in CBCN ( $p=0.049$ ). In all cases, the voicing percentage with regard to stop duration was lower when the segment appeared in the context [aCa] (see Figure 5).

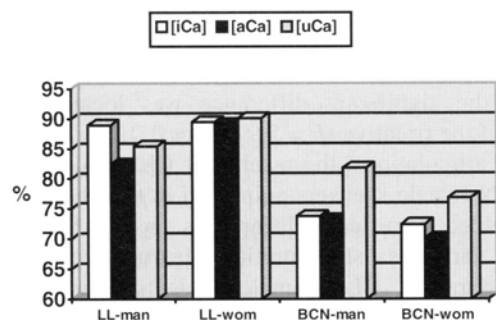


Figure 5. Voicing percentages in the plosive element of voiced affricates.

## 5. CONCLUSIONS

Our results confirm that voiced alveolo-palatal affricates in Catalan undergo a pronounced process of devoicing that begins clearly in the fricative segment. The two spectrograms below (Figure 6) illustrate this finding. They correspond to the sequence *desitja* ("s/he wishes") that contains the voiced consonant group in the vowel context [iCa]. The first graph shows the production of a CBCN female subject, and the second graph shows that of a CLL male subject.

Furthermore, devoicing is significantly affected, to a greater or lesser extent, by a number of factors: 1) The subjects' dialect: devoicing is more evident in the CBCN than CLL. 2) The frequency of use of stimuli: the higher the frequency, the shorter the duration of segments and the more devoicing in CBCN. However, there is less devoicing in CLL in relation to plosive segments, for fricatives are not affected by this variable. All this might be due to a likely effect of writing on LF. 3) The vowel

context: devoicing is more marked in the vowel context of mid-vowels. 4) The number of syllables in the word: the shorter the word, the lower the voicing percentage of the plosive in CBCN. However, the position of stress in the word does not seem to have an effect on devoicing.

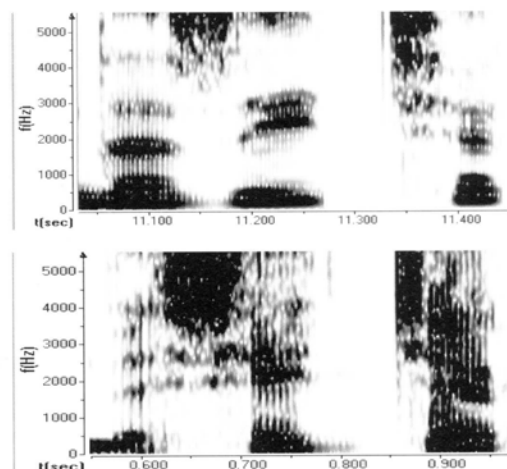


Figure 6. Spectrograms of sequence *desitja*

The phonological status of Catalan allows us to observe that the difference between voiced and voiceless affricates is not significantly productive [2], and thus devoicing is more pronounced in voiced articulations. The phenomenon of devoicing can be understood as a simplification of the system. This idea is further supported by the comparison between the Catalan dialects of Barcelona and Lleida, since various studies have shown that the dialect of Lleida is more conservative than that of Barcelona [4]. Based on this, one might infer that devoicing does not arise from a situation of language contact. Rather, it is the result of the natural course of evolution towards the principle of linguistic economy.

## ACKNOWLEDGEMENTS

We would like to thank Natalia Fullana for discussion of this material. This research was supported by GENCAT- Grup de Recerca Consolidat: "Grup de Fonètica Experimental", Reference # 2001SGR00425; by SEUID: "Modelo de organización articulatoria y cambio fonético, Reference #BFF2000-0075-C02-02; and by SEUID: "VALDIC", Reference # BFF2001-3798.

## REFERENCES

- [1] F. Alamon, *Anàlisi espectrogràfica dels sons fricativs i africats prepalatals de la varietat lleidatana del català Nord-Occidental*. Unpublished Ph.D. thesis. Lleida: Universitat de Lleida, 1985.
- [2] J.Z. Mier, "Estudi sociolingüístic de certs aspectes de la llengua catalana", *Treballs de Sociolingüística Catalana*, vol. 6, pp.33-112, 1986.
- [3] A.M. Fernández-Planas and M.A. Pradilla-Cardona, "Características de las africadas alveolopalatales del catalán oriental central", *Actas del V Congreso de Lingüística*, León, 2002.
- [4] D. Recasens, *Fonètica descriptiva del català*, Barcelona: IEC, 1991.
- [5] V. Salcioli, "Anàlisi espectrogràfica de les prepalatals del català parlat a Barcelona", *Anuario de Filología*, Universitat de Barcelona, pp.533-550, 1981.

