Front Cover: Forecourt Mosaic, Parliament House, Canberra

Photography: D. Paterson, Centre for Media Resources
University College, ADFA

Eighth Australian International Conference on
SPEECH SCIENCE AND TECHNOLOGY-PROCEEDINGS 2000

SST-2000 SST-2000 SST-2000 SST-2000 SST-2000

Proceedings of the
Eighth Australian International Conference on

SPEECH SCIENCE AND TECHNOLOGY

Canberra, December 2000

PROCEEDINGS OF THE EIGHTH AUSTRALIAN INTERNATIONAL CONFERENCE ON

SPEECH SCIENCE AND TECHNOLOGY

Canberra
5-7 December 2000

Edited by

Michael Barlow
University of NSW/ADFA

With Assistance from

Philip Rose
Australian National University

Australian Speech Science and Technology Association (Inc)
Canberra 2000

ISSN 1039-0227
ISBN 0 9588579 8 9

Cover Picture: Photograph of Parliament House, by David Paterson. M. Photog. Mosaic pavement, Parliament House forecourt. Designed by Michael Nelson Tjakamarra and fabricated by William McIntosh, with Aldo Rossi and Franco Colossi.

FOREWORD

SST-2000 is the eighth in the biennial series of Australian International Conferences on Speech Science and Technology. It was held at the Australian National University from the 5th to the 7th of December 2000. The conference series is organised by ASSTA (the Australian Speech Science & Technology Association) Inc.

SST-2000 sees the series "come full circle" by returning to its city of origin Canberra, after having been hosted by most of the capital cities and centres of speech research in Australia: SST-86, the first, was held in Canberra; with SST-88 in Sydney; SST-90 in Melbourne; SST-92 in Brisbane; SST-94 in Perth and SST-96 in Adelaide. SST-98 was a special-case, run as an adjunct to the larger ICSLP-98 and specially targeted at postgraduate students working in the speech field. It is illuminating to look back through previous proceedings (and memories of those conferences) with an eye both to the indelible and ephemeral qualities that have marked the SST series.

Clearly, the goal of the SST series, since its inception in 1986, has been to serve as a forum at which Australian and international researchers working in the multidisciplinary fields of speech science and speech technology may come together to freely share ideas and interactions. I believe that to-date there can be little doubt that the series has succeeded in that role. That said though, there is no room for complacency in the organisation or vision that drives the SST series, if the series is to maintain its key and central role.

SST-2000 has seen a number of innovations aimed at strengthening the conference. Perhaps chief amongst these has been the far more rigorous review process. For the first time full-paper submission for review has been offered as an option, with authors free to choose from that or the traditional extended abstract. A comprehensive international and national review team has been employed, and this process has been facilitated by the use of electronic submission and review: greatly speeding and standardising the process. Indeed Internet technology has proved vital as an enabler for the conference, with the web site serving as a clearing-house for submissions and reviews as well as the other detailed information concerning conduct of the conference (programme, presentation details, awards, etc.).

In all there are eighty papers in the proceedings, organised alphabetically by major topic, and within topic alphabetically by first-author's surname. It is pleasing to see the depth and diversity of Australian (and international) research that these papers represent. I would like to take the opportunity to publicly congratulate Jennifer Elliot, the winner of the ASSTA New Researcher Award, as well as to thank my fellow organising committee members and the conference attendees for their efforts and involvement in SST-2000.

Michael Barlow
Chairperson SST-2000

SPONSORS

Cochlear Pty. Ltd.
School of Computer Science, UNSW/ADFA
Appen Speech Technology Pty. Ltd.
School of Language Studies, ANU

ORGANISING COMMITTEE

Chairperson	Michael Barlow	The University of NSW / ADFA
Secretary	Michael Barlow	The University of NSW / ADFA
Treasurer	Shunichi Ishihara	The Australian National University
Technical Program & Proceedings	Michael Barlow Philip Rose	The University of NSW / ADFA The Australian National University
Publicity	Roland Goecke	The Australian National University
Tutorial Day	Frantz Clermont	The University of NSW / ADFA
Sponsorship	Michael Wagner	The University of Canberra
ASSTA Liaison	Bruce Millar	The Australian National University
Web Page Maintainer	Michael Barlow	The University of NSW / ADFA

Corporate Members of ASSTA Inc.

ASSTA Inc. is pleased to acknowledge the following companies as its Corporate Members during 2000.

Appen Pty Ltd
Cochlear Ltd
CRC for Cochlear Implant and Hearing Aid Innovation
Motorola Australian Research Centre
Syrinx Speech Systems Pty Ltd

REVIEW PROCESS

All submissions (whether full-paper or extended abstract) to SST-2000 were blind peer reviewed. The process was overseen by a Technical Programme Committee of two members who coordinated the entire process. Reviewers were drawn from two boards: a National (Australian) Review Board and an International Review Board.

A sub-committee of four members was also formed to select a winner for the ASSTA New Researcher Award (NRA).

Membership of those boards and committees are found below. All members of the Review Boards listed contributed to the review process.

TECHNICAL PROGRAM COMMITTEE

Michael Barlow
Philip Rose

ASSTA NEW RESEARCHER AWARD COMMITTEE

Michael Barlow
Frantz Clermont
Bruce Millar
Philip Rose

INTERNATIONAL REVIEW BOARD

William Ainsworth
Toomas Altosaar
Frederic Berthommier
Steven Bird
Matts Blomberg
Elizabeth Botha
Nick Campbell
Martin Cooke
Christoph Draxler
Kjell Elenius
Mark Forsyth
Sadaoki Furui
Phil Green
Shuichi Itahashi
Jagath-Kumara
Chris James
Cheolwoo Jo
Beth Logan
Doug O'Shaughnessy
Tomoko Matsui
Parham Mokhtari
Tuan Pham
Justus Roux

NATIONAL REVIEW BOARD

Eliathamby Ambikairajah
Peter Blamey
Denis Burnham
Frantz Clermont
Chris DeSilva
Jan van Doorn
Helen Fraser
David Grayden
John Ingram
Robin King
Bruce Millar
Jenni Oates
Kuldip Paliwal
Roberto Togneri
Michael Wagner

SUBMISSIONS ACCEPTED ON THE BASIS OF FULL-PAPER REVIEW

Listed below are those submissions to SST-2000 which were **reviewed and accepted on the basis of the full-paper.** This separate list is provided because authors submitting to the conference were given the choice of either submitting a full paper, or extended abstract, for review.

All submissions to the conference were blind (all author details excised from the submission) peer-reviewed by members of a National and International Review Board. The process was overseen by the Technical Programme Committee who assigned reviewers for each submission received, together with collating the review results.

ACCEPTED FULL PAPERS

Listed below, and ordered on the basis of first author's surname, are all submissions accepted for presentation at SST-2000 that were submitted and reviewed as full papers.

Ahmed B., and Holmes W.H.
Objective and subjective performance measures for voice activity detectors

Athaudage C., Bradley A.B., and Lech M.
Efficient compression of melp spectral parameters using optimized temporal decomposition

Barlow M., Watson B., Tsoi A-C., and Downs T.
A-priori selection of cohort sets for a speaker verification system: issues and insights

Barlow M., and Wagner M.
Perceptions of identity, gender and idiolect in prosodically altered speech using a composite model approach

Blamey, P., James C., and Martin L.
Sound separation with a cochlear implant and a hearing aid in opposite ears

Burnham D., Ciocca V., Lauw C., Lau S., and Stokes S.
Perception of visual information for cantonese tones

Carrera-Sabaté J., Fernández-Planas A.M., Matas-Crespo J., Ortega-Escandell A.
Differences in vowel quality in two Catalan dialects. Data from MDS.

Carson-Berndsen J., and Walsh M.
Interpreting multilinear representations in speech

Cassidy S., Welby P., McGory J., and Beckman M.
Testing the adequacy of query languages against annotated spoken dialog

Dines J., Sridharan S., and Moody M.
Compression of speech for mass storage using speech recognition and text-to-speech synthesis

van Doorn J.
Does artificially increased speech rate help?

Elliott J.
Auditory and F-pattern variations in Australian okay: a forensic phonetic investigation

Elliott J.
Comparing the acoustic properties of normal and shouted speech: a study in forensic phonetics

Epps J., and Holmes W.H.
Wideband speech coding at narrowband bit rates

Flax M., Ambikairajah E., and Holmes W.H.
Improved auditory masking models

Goecke R., Tran Q.N., Millar B., Zelinsky A., and Robert-Ribes J.
Validation of an automatic lip-tracking algorithm and design of a database for audio-video speech processing

Ishihara S.
Continuous linguistic tonetic representation using polynomial residuals

Ishihara S.
Linguistic-tonetic differences in target-tone realisation: standard vs. Kagoshima Japanese

Ishihara S.
The exponential nature of F0 target tone interpolation

Kim H-G., Obermayer K., Bode M., and Ruwisch D.
A 1.6 kbps speech codec using spectral vector quantization of differential features

Kim H-G., Obermayer K., Bode M., and Ruwisch D.
Real-time noise cancelling based on spectral minmum detection and diffusive gain factors

Kinoshita Y.
Effective F2 as parameter in Japanese forensic speaker identification

Kinoshita Y., and Maindonald J.
Statistical quantification of differential vowel comparability in forensic phonetic samples

Kovtonyuk A., Kalyuzhny, and Semenov
Adaptive Kalman filtering of speech signals, based on a block model in the state space and vector quantization of auto regressive features

Lucey S., Sridharan S., and Chandran V.
A improvement of automatic speech reading using a intensity to contour stochastic transformation

McCowan I., Moore D., and Sridhran S.
Speech enhancement using near-field superdirectivity with an adaptive sidelobe canceler & postfilter

Martin L, Blamey P., James C., Galvin K., and Macfarlane D.
Adaptive dynamic range optimisation for hearing aids

Mason M., Sridharan S., and Chandran V.
A comparison of two hybrid audio coding structures incorporating discrete wavelet transforms

Millar B.
Prospects for speech technology in the Oceania region

Ming L., Junkawitsch J., and Yu T.
An incremental approach to selection of well balanced corpus

Myers S., Pelecanos J., and Sridharan S.
Two speaker detection by dual gaussian mixture modelling

Pelecanos J., Myers S., and Sridharan S.
Rapid channel compensation for one and two speaker detection in the NIST 2000 speaker recognition evaluation

Rose P.
Hong Kong Cantonese citation tone acoustics: a linguistic tonetic study

Rose P.
Wenzhou dialect disyllabic lexical tone sandhi with first syllable entering tones

Tsurutani C. , and Ingram J.
Perception of moraic timing by English learners of Japanese

Veprek P., and Bradley A.B.
Hierarchical speech compression for storage - a two-level approach

Wark T., Sridharan S., and Chandran V.
A comparison of static and dynamic classifier performance for multi-modal speaker verification

Wojdel J. and Rothkrantz L.
Silence detection and vowel/consonant discrimination in video sequences

Wong E., Pelecanos J., Myers S. and Sridharan S.
Language identification using efficient gaussian mixture model analysis

CONTENTS

KEYNOTE PAPERS

DIFFERENCES IN VOWEL QUALITY IN TWO CATALAN DIALECTS. DATA FROM MDS.

Josefina Carrera-Sabaté°*, Ana M. Fernández-Planas°, Josep Matas-Crespo° and Alícia Ortega-Escandell°.

°Universitat de Barcelona,*Universitat de Lleida.

ABSTRACT

Phonetic descriptions which concern themselves with dialectal distinctions have different goals: a) general descriptions of all the linguistic domain and b) more specific detail focusing on the differences between dialects, such as "lleidatà" and "barceloní". Following this second line of dialectal contrast, this paper aims at demonstrating acoustical differences of openness between the middle vowels of the anterior series of two Catalan dialects: "barceloní" (Eastern Catalan) and "lleidatà" (Western Catalan). The data have been statistically treated by means of MultiDimensional Scaling (MDS), and the configurations obtained allow us to observe significant differences between open and closed vowels in both dialects.

1. INTRODUCTION

All languages present phonic features which are detected differently according to dialectal differences, so that 1) they can be easily distinguished, 2) are evident in the production act but are difficult to perceive, or 3) are imperceptible. In the Catalan vowel system, some differences are very difficult to perceive but are clearly marked from an acoustic point of view. We will focus on two vowels that are a good example of this.

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, Roussillon 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). On the one side, the vocalic differences between these two diasystems are based on the fact that in non-stressed position the Eastern dialects have three vowels and the Western ones, five; on the other side, in stressed position, there are differences between both diasystems in the openness of the vowels. Both Central Eastern Catalan and Western Catalan have two different middle vowels of the anterior series in stressed position : /e, ɛ/ (e.g.: [seu]=his/her/their vs. [sɛu]=cathedral). However, the realizations /e/ and /ɛ/ in both dialects are different acoustically, even though this difference is not easily perceived. As a consequence, different phonic distributions occur.

The middle vowels of Eastern and Western Catalan have been reported to have different vocalic openness. Using perceptual judgements basically, several authors coincided in affirming that the stressed middle vowels of Eastern Catalan were more open that Western Catalan ones (cf. Badia, 1973; Veny, 1983; Recasens, 1986a, 1991). Following this conception, the purpose of this paper is presenting a contrastive analysis of the acoustic differences between utterances by speakers of Central Eastern Catalan, on the one hand, and North-Western Catalan, on the other. Besides, we intend to validate these dialectal contributions using a statistical technique known as MultiDimensional Scaling (MDS).

2. MULTIDIMENSIONAL SCALING (MDS)

This technique is based on the assumption that, for a group of elements, a matrix of experimental proximities can be obtained from which a t-dimensional space is created (where t is equal to the number of dimensions) and the elements are represented in such a way as to ensure that the

distances among the obtained points are equivalent to the proximities experimentally found. The minimum condition of equality establishes that the rank order of the distances must be equal to the rank order of the distances among the points in the configuration. It must be pointed out that the work by Takane, Forrest & Leeuw (1977), where the algorithm ALSCAL, based on the *alternating least squares* method, was developed, improves the creation of the resultant configuration computationally. In addition, this technique offers the advantage of making it possible to represent the objects in a geometric space. In order to have an easily understandable graphic representation, the maximum number of dimensions constituting this space should be three. The data analyzed by means of MDS do not need to be normally distributed in order to obtain a good configuration.

3. METHODOLOGY

The data constitute a sample of laboratory speech recorded in optimum conditions for their ulterior analysis. They were uttered by six men (three for each dialectal variant) from 22 to 30 years of age, whose accent was not affected or influenced by Spanish. The speakers come from two specific geographic areas: Lleida (zone pertaining to the North-Western dialect) and Barcelona (zone pertaining to the Central Eastern dialect).

The anterior middle vowels [e, ɛ][1] have been uttered in symmetric CVC sequences; these vowels have been preceded and followed by consonants with different articulatory characteristics: bilabial stop ([p]), denti-alveolar stop ([t]), alveolar nasal ([n]), alveolar fricative ([s]), trill ([r]) and lateral ([ɫ]). The result of this combination of consonants and vowels as been a set of logatomes uttered within the following carrier phrase: *diu CVC quan vol (He says CVC when he wants)*. The sequences were uttered three times by each informant.

The acoustic analyses were performed at the Laboratory of Phonetics of the University of Barcelona using the CSL4300B and consisted of the frequency measurement (F1, F2, F3[2]) in the steady-state of the investigated sounds using LPC (Martínez-Celdrán, 1998). The statistical analysis of the data was performed with the package SPSS 9.0. The technique employed was MDS.

4. RESULTS

It is evident from the results that the data are distributed in two dimensions according to their specific weight when the groups are established. These dimensions are: 1) openness and 2) the parameter called dialect, as can be observed in the graph of figure 1 (Stress= ,091; RSQ= ,962). In this graph openness is represented on the x axis and dialectal differences on the y axis.

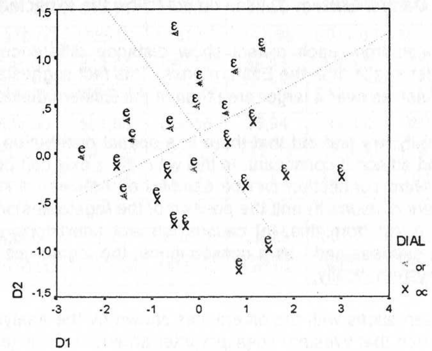
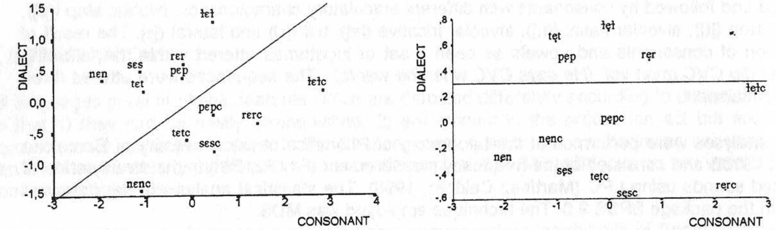


Figure 1. Dialect/Openness[3]

In the graph the vowels organize themselves according to openness and dialect: the top part corresponds to the utterances from North-Western Catalan (Lleida); and the bottom, to the Central Eastern dialect from Barcelona; on the right, the open vowels; and, on the left, the closed ones. It is evidence that each dimension represents a clearly differentiated space that coincides with the phonetic parameters investigated. Only one exception to the openness parameter can be found, corresponding to an open vowel within the closed vowels space; there are two exceptions to the parameter "dialect" corresponding to two vowels from the Central Eastern Catalan. In a previous study with the two vowel qualities of the middle vowels the results were very similar; in it, the dimensions of vowel quality and openness were perfectly differentiated without any intersection of the spaces and only one case was an exception as for dialect (Carrera-Sabaté et alii, 1999).

Assuming that both phonetically and statistically the openness distinction is reflected perfectly in our data without intersections, in a second analysis of the data we have divided the parameter in order to get deeper into the aspect we were most interest in: the dialectal distinction of the anterior middle vowels. As a result, we have decided to use MDS again in two dimensions: dialect and a new parameter we have denominated consonantal context adjacent to the vowel studied, since adjacent consonants are known to affect vocalic formants. These results appear on the following graphics in figure 2:



A. [ɛ] (Stress=0.028; RSQ=0.996) B. [e] (Stress=0.001; RSQ=0.999)

Figure 2

Among open vowels there is regularity of distribution associated to dialect. Only two logatomes with vowel [e] (*ses* and *nen*) from Central Eastern Catalan do not follow the expected tendency.

Apart from this, the utterances from each dialect show distance differences. The vowels of the Western dialect occupy a wider space than the Eastern ones. This fact suggests that [e] and [ɛ] in the Western dialect expand themselves over a larger area than in the Eastern dialect.

If we look into the data carefully, we find out that there is a spatial distribution among the logatomes according to vowel quality and adjacent consonant. In this way, the x axis can be correlated with vowel F2. This is why a straightforward connection can be established between a lower F2 of the studied vowels (caused by the adjacent consonant) and the position of the logatomes on the right hand-side of the graph ($r=0.99$; $p<0.01$). Apart from this, [n] causes formant alterations visible in the adjacent vowels, as Recasens (1991) exposes and, as a consequence, the logatomes with [n] appear on the left hand-side of the graphs systematically.

Finally, connecting these observations with the differences shown by the analysis of the logatomes in both dialects it can be concluded that Western speakers utter anterior vowels [e] and [ɛ] in all contexts ([p], [t], [n], [s], [r] and [ɫ]) with a lower F2 than speakers of the Eastern dialect, as can be inferred from the following table and the graphs in figure 3:

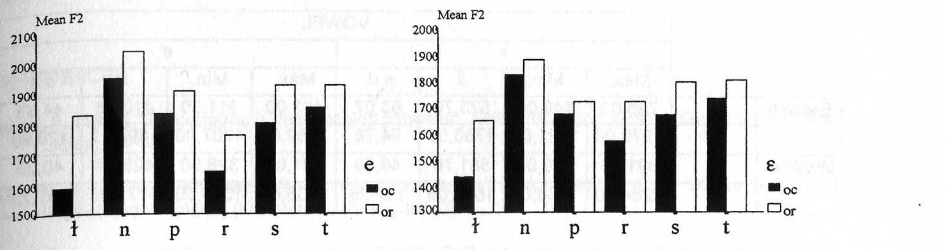


Figure 3

			VOWEL							
			ɛ				e			
			Max.	Min.	x̄	s.d.	Max.	Min.	x̄	s.d.
East.	p	F1	587,00	518,00	554,44	25,17	432,00	362,00	400,67	29,92
		F2	1780,00	1676,00	1718,22	36,84	2022,00	1814,00	1898,89	87,73
	t	F1	604,00	483,00	542,89	42,38	466,00	362,00	408,33	41,60
		F2	1901,00	1711,00	1799,11	61,42	2005,00	1866,00	1918,22	46,52
	n	F1	674,00	501,00	593,11	61,08	466,00	311,00	393,22	63,19
		F2	1970,00	1797,00	1881,67	60,75	2160,00	1901,00	2031,56	92,95
	s	F1	622,00	449,00	543,00	65,98	414,00	345,00	375,67	30,87
		F2	1884,00	1659,00	1793,22	83,68	2126,00	1780,00	1918,22	123,92
	r	F1	691,00	501,00	604,44	71,31	466,00	397,00	443,22	22,74
		F2	1797,00	1659,00	1720,44	47,46	1884,00	1607,00	1755,11	78,42
	ɫ	F1	725,00	501,00	604,33	75,28	483,00	414,00	448,88	20,56
		F2	1745,00	1521,00	1647,33	61,54	1918,00	1711,00	1823,00	80,38
West.	p	F1	639,00	570,00	606,33	23,61	466,00	380,00	433,56	27,88
		F2	1935,00	1538,00	1674,22	129,36	1987,00	1693,00	1829,67	109,45
	t	F1	604,00	553,00	575,67	17,00	466,00	345,00	418,00	36,47
		F2	1970,00	1555,00	1731,67	147,66	2074,00	1659,00	1847,00	155,85
	n	F1	691,00	449,00	560,22	88,21	466,00	328,00	389,22	48,97
		F2	2264,00	1659,00	1827,78	203,74	2108,00	1780,00	1945,00	112,97
	s	F1	604,00	501,00	554,56	35,94	466,00	380,00	414,44	28,64
		F2	2074,00	1486,00	1672,22	193,03	2039,00	1590,00	1799,11	168,37
	r	F1	656,00	553,00	583,33	31,84	483,00	397,00	443,11	27,22
		F2	1814,00	1434,00	1574,11	153,92	1918,00	1348,00	1641,56	209,95
	ɫ	F1	639,00	570,00	610,11	22,93	501,00	380,00	454,10	39,07
		F2	1676,00	1330,00	1438,00	126,02	1832,00	1330,00	1589,60	181,67

Table 1

		VOWEL							
		ε				e			
		Máx.	Mín.	x̄	s.d.	Máx.	Mín.	x̄	s.d.
Eastern	F1	725,00	449,00	573,70	63,07	483,00	311,00	410,96	44,63
	F2	1970,00	1521,00	1760,00	94,76	2160,00	1607,00	1892,11	120,90
Western	F1	691,00	449,00	581,70	46,69	501,00	328,00	425,93	40,20
	F2	2264,00	1330,00	1653,00	197,39	2108,00	1330,00	1771,95	197,72

Table 2

Graphic number 3 and tables 1 and 2 show that the highest values appear when the vowel is adjacent to an alveolar nasal and the lowest ones, when it is adjacent to velarised laterals and trills. This results are coincident with those by Recasens (1986b) and Carrera-Sabaté et alii (1999). This fact is particularly evident in the results for the North-Western dialect (in the Eastern one the values for vowels adjacent to bilabial stops are also lower). This finding is not unexpected, since graphic 2 showed that the frequencial values for the speakers from Lleida expand themselves in a wider space than those for speakers from Barcelona. For instance, mean values for the F2 of [ɛ] in Lleida's dialect go from 1,438 Hz when it was adjacent to [ɫ] to 1,827 Hz when it was adjacent to [n], while the average value in all consonantal contexts is 1,653 Hz. For Barcelona dialect, the average values were: 1,647 Hz (adjacent to [ɫ]) and 1,881 Hz (adjacent to [n]), being the general average 1,760 Hz.

5. CONCLUSIONS

The results from the acoustic data from our experiment show that there is a well-established openness distinction in the middle anterior vowels between the North-Western dialect from the area of Lleida and that of Barcelona, belonging to the Central Eastern dialect. Furthermore, it is clear that Western vowels present a lower F2 than the Eastern ones systematically. As a result, we can affirm that middle vowels are more open in North-Western Catalan than in Central Eastern Catalan.

As a corollary, we wish to point out that, even though perceptually the interdialectal distinction between the middle vowels is not always obvious, since it is not categorical but gradual between dialects (Recasens, 1992; Fernández-Planas et alii, in press), it is a well-established distinction from an acoustic point of view.

Another conclusion that deserves being remarked is that MultiDimensional Scaling (MDS) has proved to be an efficient tool for our aims. Even though it is a complex technique, it has a great advantage: analysis and understanding are quickly achieved, since the target groups are well delimited and this is visually evident.

NOTES

1. In a previous study we found out that the posterior middle vowels of Catalan ([o, ɔ]) did not follow the same pattern as the anterior ones, so we have decided to focus on the latter in this paper

2. Previous analyses demonstrated F3 did not supply relevant information for our purposes. Consequently, we did not use these data for our study.

3. «Or» refers to the Català oriental (Estern Catalan) and «oc» to de Català nor-occidental (Western Catalan).

6. REFERENCES

Alamon, F. (1984) "Espectrografia dels vocoids catalans", Folia Phonética, (Estudi General de Lleida: Lleida) 79-88.

Badia, A. M. (1973) "Phonétique et phonologie catalanes" in A.M. Badia & G. Straka (eds.): La lingüistique Catalane, (Klincksieck: Paris), 115-166.

Carrera-Sabaté, J. (1999) L'alternança a/e al Segrià. PhD dissertation (unpublished). Universitat de Barcelona.

Carrera-Sabaté, J; Fernández-Planas, A.M. and Matas-Crespo, J. (1999) "Estudi contrastiu de vocals mitjanes del català oriental central i nord-occidental", Proceedings of the 1 Congress of Experimental Phonetics. Tarragona, 143-149.

Fernández-Planas, A.M; Carrera-Sabaté, J. and Matas-Crespo, J. (in press) Estudio perceptivo de vocales medias del catalán oriental central y del catalán noroccidental.

Gili y Gaya, S. (1931) Estudi fonètic del parlar de Lleida. Miscel·lània filològica dedicada a D. Antoni M. Alcover, (Círculo de Estudios: Palma de Mallorca) 241-255.

Kruskall, J.B. (1964) "Nonmetric multidimensional scaling", Psychometrika, 29, 1-27.

Martínez-Celdrán, E. (1998) Análisis espectrográfico de los sonidos del habla, (Ariel Practicum S.A:Barcelona)

Recasens, D. (1991) Fonètica descriptiva del català, (IEC: Barcelona).

Recasens, D. (1986a) Estudis de fonètica experimental del català oriental central, (PAM: Barcelona).

Recasens, D. (1986b) "Temes de variació dialectal", Actes del Setè Col·loqui internacional de llengua i literatura catalanes, (PAM: Bacelona), 523-544.

Recasens, D. (1992) "Trets dialectals imperceptibles", Escola catalana, 293, 14-18.

Takane, Y; Forrest, W. and Leeuw, J. (1977) "Nonmetric individual differences multidimentional scaling: an alternating least squares method with optimal scaling features", Psychometrika, 42, 1, 7-67.

Veny, J. (1983): Els parlars catalans, (Raixa: Palma de Mallorca).