

Phonological vowel reduction in four Catalan varieties

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ABSTRACT

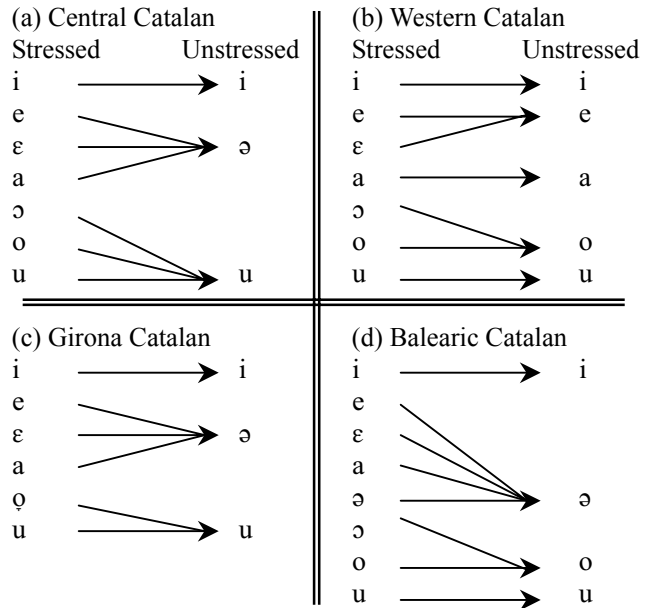
To test predictions made by theories of phonological vowel reduction, we require quantitative data to verify and make more precise impressionistic descriptions. Catalan, with phonological vowel reduction in several regional varieties, provides an ideal case study. This paper offers a quantitative description of the stressed and corresponding unstressed vowels of female speakers representing four distinct regional varieties of Catalan – that of Berguedà (representative of Central Catalan – the standard variety), Lleida (Western Catalan), Girona (a northern variety), and Palma (Balearic Catalan). Target vowels appeared in nonsense words which were uttered within a carrier phrase. The formant values for F1-F3 are reported here and compared to impressionistic descriptions.

1. INTRODUCTION

Regional varieties of Catalan differ with respect to the makeup of their stressed and unstressed vowel inventories. Central Catalan allows seven vowels (/i, e, ε, a, ə, o, u/) in stressed position and three vowels (/i, ə, u/) in unstressed position ([7], [8], [10]). The vowel inventories of the other varieties are shown in figure (1) which also indicates the mapping relationships between stressed and unstressed vowels (based on diagrams and descriptions in the work of Mascaró [7], [8], and Recasens [10]).

The Catalan varieties in figure (1) exhibit vowel reduction in the phonological sense – the number of phonemes found in unstressed position is reduced relative to the number of vowel phonemes found in stressed position. Phonology has no trouble describing vowel reduction, but it does have trouble explaining it. Recent phonological models which incorporate phonetic information directly into the theory (such as Dispersion Theory [3], [9] as well as work by Crosswhite [2] and Herrick [4]) have had greater explanatory success compared with previous theories. However, such phonetically based theories cannot be tested without quantitative phonetic data. Thus, the primary goal of this paper is to contribute quantitative data which can be used to help develop and test a more phonetically oriented theory of phonological vowel reduction. An additional interest is verifying the extent to which the quantitative data matches the phonological descriptions. How accurate are the mapping relationships shown in figure (1)? For example, do the unstressed versions of [e, ε, a] really converge on

Figure (1)



schwa in Central and Girona Catalan? Or are there significant differences between [ə] which corresponds to stressed [e] or [ε] compared with [ə] which corresponds to stressed [a]? In addition to descriptive questions such as these, this study serves as the initial building block for a larger research project ([4]) which aims to test for a correlation between vocalic inventory size and position of vowels within the vowel space (see also Adaptive Dispersion Theory [5], [6]). The remainder of this paper describes the methodology and results for a phonetic study of Catalan vowels designed to verify impressionistic descriptions and serve as a base for further inquiries into phonological vowel reduction.

2. METHODOLOGY

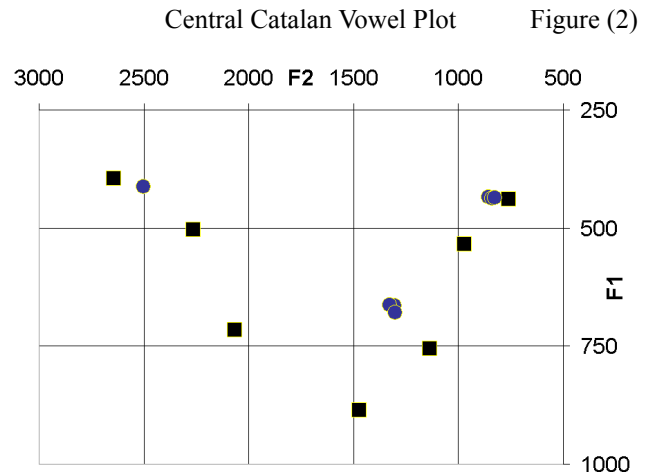
For each of the different regional varieties studied, three native speakers were recorded uttering nonsense verbs containing the stressed (and corresponding unstressed) vowels of their variety. All recordings were made in Catalonia, all speakers were female college students, and a 'native' was defined as someone who spoke Catalan as their primary language and came from a family in which both parents spoke primarily Catalan. For the recordings, speakers were shown several verbs – one for each of the vowels allowed in stressed position in their variety (seven for Central and Western, six for Girona, and eight for Balearic Catalan), and they were asked to conjugate each

verb into the third person singular form and repeat it ten times using the carrier phrase ...*sempre* _____ *a la nit* ([*sempɾə* _____ *ələnɪt*] “always _____ at night”). After this, the speakers were asked to conjugate the verbs into their infinitival forms and repeat them ten times each within the same carrier phrase. Third person forms were of the shape [*bVɾə*] (where the target vowel ‘V’ is stressed), and the infinitival forms were of the shape [*bV'pa*] (target vowel unstressed). More concretely, when native speakers were shown *bapes* [*ˈbapəs*], they had to produce the third person singular form *bapa* ([*ˈbapə*]) and the corresponding infinitival form *bapar* ([*bəˈpa*]). For Central Catalan, this gives a total of 140 vowel tokens per speaker; 70 stressed tokens (10 for each vowel) and 70 unstressed tokens (10 tokens for each of the corresponding unstressed vowels). Thus, even though [e, ε, a] reduce to [ə] there are 10 tokens for [ə] corresponding to [e], 10 more corresponding to [ε], and another 10 corresponding to [a]. This allows us to confirm whether [e, ε, a] do in fact reduce to the same vowel ([ə]) or not.

All subjects were recorded on a DAT recorder using a headset microphone. Recordings were digitized at 44.1kHz, (Hahn) band-pass filtered from 0-6000Hz, and measured by LPC analysis with a 25ms window using the PRAAT phonetics software package ([1]). The location for measurement of the three vowel formants (F1-F3) was determined as follows: if F1 had a single peak, F1-F3 were measured at the point where F1 reached its peak; if no unique max could be found for F1 (if F1 contained multiple peaks or if F1 were a constant cline), the measurement was made at the peak (or valley) of F2. If there was no unique max or min for F2, the measurement was made at the mid-point of the vowel (as determined by eye).

3. RESULTS & ANALYSIS

The data for the individual speakers have been combined within each regional variety and the combined data are presented in two forms; one visual and the other numerical. The visual form plots the mean values of F1 and F2 for each vowel as a graph (figures (2-5)). The stressed vowels are shown as solid squares, and the corresponding unstressed vowels are shown as solid circles. In some cases, values are nearly identical and the symbols overlap. The data have also been presented in a table containing the means and standard deviations for F1-F3 (tables (1-4)). Each table has a column for stressed vowel values (with sub-columns for F1-F3) and a column for the corresponding unstressed vowel values (with sub-columns for F1-F3). Each row contains information about a single vowel – the mean formant values for F1-F3 in stressed position followed by the mean values for F1-F3 in unstressed position. In cells containing numbers, the upper number is a mean formant value (in Hertz), and the lower number enclosed in parentheses is the standard deviation. Since three speakers represent each region and there are ten measurements per vowel (per speaker), each cell contains the mean value of

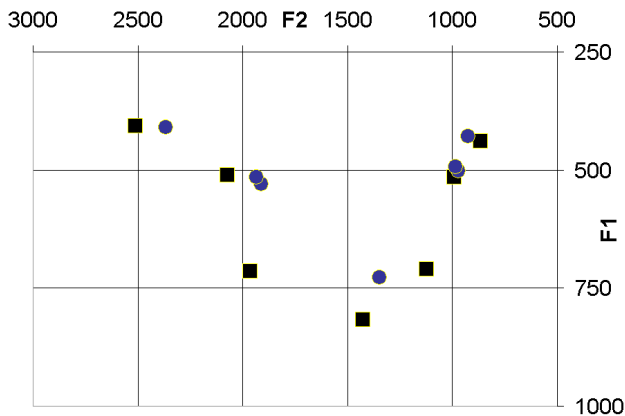


Central Catalan Data (in Hertz) Table (1)

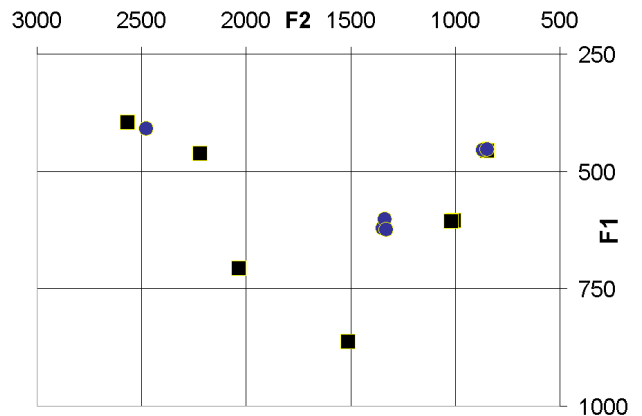
| | Stressed | | | Unstressed | | | |
|---|-------------|---------------|---------------|-------------|---------------|---------------|---|
| | F1 | F2 | F3 | F1 | F2 | F3 | |
| i | 394 (58) | 2645 (138) | 3145 (269) | 413 (26) | 2502 (119) | 2919 (163) | i |
| e | 503 (29) | 2265 (206) | 3015 (152) | 664 (77) | 1304 (120) | 2694 (116) | ə |
| ε | 716 (24) | 2067 (124) | 3025 (144) | 662 (91) | 1329 (168) | 2743 (120) | |
| a | 886 (54) | 1472 (153) | 2915 (155) | 679 (87) | 1303 (144) | 2771 (179) | |
| o | 755 (56) | 1138 (104) | 2882 (201) | 435 (30) | 856 (96) | 2786 (243) | u |
| o | 534 (23) | 971 (43) | 2913 (227) | 438 (28) | 841 (88) | 2827 (338) | |
| u | 439 (55) | 761 (46) | 2892 (307) | 436 (34) | 828 (76) | 2777 (244) | |

thirty tokens. At this point we can begin answering some of the questions posed above. First, do the quantitative data for the stressed and unstressed vowels support the impressionistic descriptions? The answer appears to be a fairly resounding “Yes”. Figures (2-5) reveal solid boxes – the symbol for stressed vowels – just where we might expect them (in the case of Girona Catalan, figure (4), the box for stressed [u] is obscured by the overlapping symbols for unstressed [u]). In Western Catalan, figure (3), the boxes for [u] and [o] are closer in proximity than other vowel pairs, but there is still a significant difference between these two vowels (see below). Furthermore, in Central, Western, and Girona Catalan, the solid circles (representing unstressed vowels) appear in roughly expected locations as well, though several of the unstressed

Western Catalan Vowel Plot Figure (3)



Girona Catalan Vowel Plot Figure (4)



Western Catalan Data (in Hertz) Table (2)

| | Stressed | | | Unstressed | | | |
|---|-------------|---------------|---------------|-------------|---------------|---------------|---|
| | F1 | F2 | F3 | F1 | F2 | F3 | |
| i | 407 (26) | 2512 (207) | 2906 (193) | 410 (23) | 2367 (208) | 2834 (145) | i |
| e | 511 (52) | 2074 (107) | 2769 (88) | 530 (53) | 1911 (126) | 2732 (53) | e |
| ε | 714 (44) | 1966 (75) | 2853 (70) | 515 (39) | 1934 (109) | 2745 (66) | |
| a | 817 (45) | 1426 (107) | 2678 (101) | 728 (48) | 1348 (90) | 2677 (92) | a |
| ɔ | 709 (37) | 1122 (55) | 2747 (121) | 502 (36) | 971 (90) | 2853 (97) | o |
| o | 516 (49) | 991 (59) | 2863 (180) | 494 (36) | 985 (94) | 2784 (144) | |
| u | 438 (25) | 866 (96) | 2817 (172) | 428 (41) | 924 (122) | 2814 (189) | u |

Girona Catalan Data (in Hertz) Table (3)

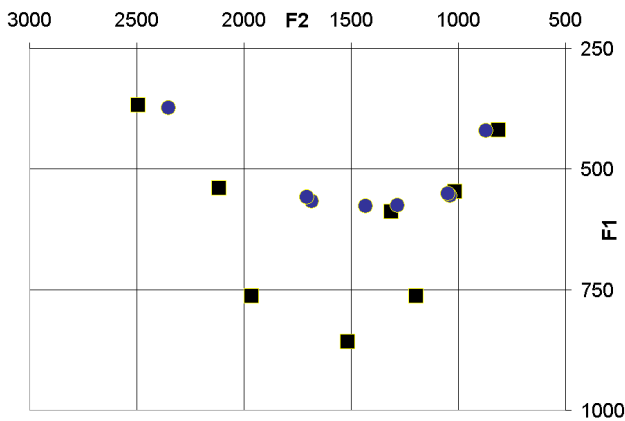
| | Stressed | | | Unstressed | | | |
|---|-------------|---------------|---------------|-------------|---------------|---------------|---|
| | F1 | F2 | F3 | F1 | F2 | F3 | |
| i | 397 (56) | 2568 (154) | 3158 (304) | 408 (41) | 2478 (202) | 2998 (266) | i |
| e | 462 (25) | 2220 (148) | 2940 (120) | 622 (60) | 1346 (108) | 2792 (176) | ə |
| ε | 707 (22) | 2036 (131) | 2924 (139) | 602 (56) | 1336 (92) | 2779 (156) | |
| a | 860 (79) | 1515 (151) | 2638 (172) | 624 (49) | 1330 (113) | 2798 (154) | u |
| ɔ | 605 (67) | 1012 (118) | 2754 (218) | 455 (28) | 863 (80) | 2735 (282) | |
| u | 456 (57) | 846 (122) | 2772 (252) | 454 (19) | 846 (86) | 2639 (316) | |

vowels appear to be somewhat centralized – in particular, the unstressed versions of /i/ for all varieties and the unstressed version of /a/ in figure (3). The data for the Palma variety, on the other hand, exhibited considerable variation with respect to the unstressed versions of /e, ε, a, ə/ - the vowels which reportedly reduce to schwa. Of the three speakers recorded, all pronounced unstressed /a/ as [ə], but two pronounced unstressed /e, ε/ as [e] rather than [ə], and one, rather surprisingly, pronounced unstressed [ə] as [e]. Impressionistic descriptions of Balearic Catalan (of which Palma is a member) note that there are some morphological exceptions to vowel reduction – particularly within the verbal paradigm ([8]), so perhaps the nonsense verbs used in this study fell into some sort of morphologically exceptional category. On the other

hand, the character of Palma vowel reduction may be changing. For a more complete discussion, see [4].

In addition to this visual inspection, the data was submitted to an analysis of variance (ANOVA) followed by a post-hoc pairwise comparison of the vowels (the Tamhane test was performed since a Levene test of homogeneity of variance showed that the variance was not equal for all vowel groups). The results of the post-hoc tests showed that the stressed vowels for *all* varieties were significantly different from one another ($p < .05$) with respect to F2, and the F1 values were significantly different when comparing front and back vowels separately (typically, [e] and [o] and [ε] and [ɔ] were not significantly different with respect to F1). In addition, these tests showed that there were no significant differences between the schwas which correspond to unstressed /e, ε, a/ or the [u]’s which correspond to unstressed /o, ɔ, u/ in Central and Girona

Palma Catalan Vowel Plot Figure (5)



Palma Catalan Data (in Hertz) Table (4)

| | Stressed | | | Unstressed | | | |
|---|-------------|---------------|---------------|--------------------|------------------------|-----------------------|-----|
| | F1 | F2 | F3 | F1 | F2 | F3 | |
| i | 368 (32) | 2494 (263) | 2963 (288) | 374 (27) | 2352 (329) | 2832 (311) | i |
| e | 539 (37) | 2118 (254) | 2841 (213) | 583/537 (38/23) | 1857/1337 (281/106) | 2806/2311 (182/49) | e/ə |
| ε | 764 (46) | 1965 (196) | 2825 (154) | 582/510 (26/35) | 1936/1251 (312/62) | 2878/2334 (190/62) | e/ə |
| a | 858 (77) | 1516 (168) | 2615 (162) | 575 (68) | 1285 (78) | 2625 (267) | ə |
| ə | 589 (35) | 1312 (84) | 2724 (204) | 552/589 (22/72) | 1622/1336 (68/97) | 2661/2607 (58/250) | e/ə |
| ɔ | 763 (53) | 1197 (67) | 2608 (117) | 556 (43) | 1038 (48) | 2622 (226) | o |
| o | 547 (34) | 1015 (73) | 2737 (163) | 551 (41) | 1048 (61) | 2605 (214) | |
| u | 420 (15) | 814 (84) | 2693 (239) | 420 (39) | 871 (47) | 2627 (248) | u |

Catalan. That is, /e, ε, a/ all reduce to the same vowel. Likewise for the mid-back vowels in Western and Balearic Catalan (/o, ɔ/ reduce to [o]) and for the mid-front vowels in Western Catalan (/e, ε/ reduce to [e]). The stressed and unstressed /a/'s in Western Catalan, however, were significantly different with respect to both F1 and F2 (unstressed /a/ maps to [a] in figure (1)). In Central Catalan, the F2 values of both stressed and unstressed /i/ and /u/ were also significantly different (though there was no significant difference for F1).

Finally, without normalizing for individual speaker

differences, nothing conclusive can be claimed about the connection between inventory size and location of vowels in the vowel space. However, the back vowels for Girona Catalan still present an intriguing picture; in the least crowded vowel space, we find the F1 values for the high and mid back vowels to be considerably different than in the other systems. An observation which, at the very least, is suggestive.

4. CONCLUSIONS

The basic findings of this study support the impressionistic descriptions of the stressed and unstressed vowel inventories for all the varieties examined (though more study is warranted for the unstressed versions of /e, ε, a, ə/ in Palma Catalan). The data gathered forms an important empirical base necessary for developing phonetically grounded models of phonological vowel reduction.

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