DIFFERENTIAL POSITIONAL NEUTRALIZATION OF BACK VOWELS IN TWO MAJORCAN CATALAN SUB-DIALECTS

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ABSTRACT

The present paper explores the patterns of unstressed vowel reduction affecting the three back vowels of Catalan: /ɔ/, /o/ and /u/. In particular, we examine two reduction patterns found in the Catalan dialect spoken on the island of Majorca: (i) the general Majorcan pattern according to which /ɔ/ and /o/ merge to [o] in unstressed position and /u/ remains different (as [u]), and (ii) a pattern found only in one small village on the island of Majorca, Sóller, according to which /ɔ/, /o/ and /u/ all merge to [u]. By means of an acoustic study, the present paper establishes that the traditional impressionistic descriptions of these sub-dialects of Catalan with respect to their back vowels are correct and that these processes are thus best described as categorical, phonological (rather than gradient, phonetic) processes.

Keywords: Unstressed vowel reduction, positional neutralization, back vowels, Majorcan Catalan

1. INTRODUCTION

Lexical stress is a well-known trigger of phonetic variation. A stress-induced process attested in many languages is "unstressed vowel reduction." The present paper explores the patterns of unstressed vowel reduction attributed to two dialects of Catalan. In particular, we are concerned with the three back vowel phonemes of Catalan (/ɔ/, /o/, /u/), which are known to exhibit different reduction patterns across Catalan dialects.

All Catalan dialects share the fact that /ɔ/, /o/, /u/ are contrastive (*dona* [ˈdɔnə] 'woman,' *dóna* [ˈdonə] 'give', *duna* [ˈdunə] 'dune') but only in stressed position; the number of back vowel categories is smaller in unstressed position in all cases.

Catalan may be divided into two major dialectal varieties, Eastern and Western Catalan. In Central Standard Catalan and most other Eastern varieties of Catalan, /ɔ/, /o/ and /u/ merge into a single phonetic category in unstressed position: /ɔ/ and /o/ are raised to [u] and thus merge with /u/ in this position [8, 11]. In Western Catalan varieties, such as in Valencian, /ɔ/, /o/ and /u/ are reduced to two contrasting phonetic categories in unstressed position: /ɔ/ and /o/ merge to [o] and /u/ remains [u]. In other words, Eastern Catalan has only [u] in unstressed position and Western Catalan has both [o] and [u]. None of the dialects uses [ɔ] in unstressed position.

Majorcan Catalan, a variety spoken on the island of Majorca, is classified as an Eastern dialect based on a long list of phonological features and processes, including the reduction patterns that affect the mid-front and the low vowels (irrelevant here). However, Majorcan Catalan shares with Western varieties of Catalan the fact that it has been described as a dialect that merges the three back vowels into two phonetic categories: /ɔ/ and /o/ are merged to [o] while /u/ remains [u]. Interestingly, the dialect spoken in one particular village on Majorca, Sóller, seems to share the vowel reduction pattern of the Eastern Catalan dialects spoken in the mainland and on the neighboring islands of Minorca and Eivissa/Ibiza, and thus it differs from the rest of the Majorcan dialects. In Sóller Catalan all three vowel phonemes are reduced to a single phonetic category, [u] [8, 11].

Sóller is a small Majorcan village of approximately 14,000 inhabitants (1.25% of the population of Majorca) that is situated on the Northwestern coast of the island. It is geographically isolated from the rest of Majorca by rugged mountains. In 1996 construction was finalized for a tunnel that communicates the village of Sóller with the main valley plain on the island, and currently the drive from the village to Palma takes about 35 minutes. Before the tunnel was built, travelers had to go through a difficult mountain pass. Unlike in the recent past, it is now common for residents of Sóller to commute daily to Palma. This raises a number of questions regarding the status of the phonetic and phonological features that characterize Sóller Catalan and distinguish it from other Majorcan Catalan varieties.

The traditional formulation of phonological rules such as those described above for unstressed vowel reduction is grounded on the assumption that they are phonetically implemented in a categorical manner. Abundant research over the past three decades, however, has shown that this is not always the case. Various phonetic studies of phonological processes, such as word-final devoicing in several languages [3, 10, 20], have reported acoustic differences be-

tween forms which, according to impressionistic descriptions, were expected to have been completely neutralized. This brought about the coinage of the term "incomplete neutralization." Interestingly, evidence of incomplete neutralization has been found for vowel mergers in languages with unstressed vowel reduction, such as Russian [7].

In the light of this, the purpose of the present production study was to investigate whether a phonetic exploration of stress-induced reduction of back vowels in two varieties of Majorcan Catalan would (i) confirm the dialectological descriptions summarized above, and (ii) verify whether the alleged mergers entail full neutralization. Due to the particular geographical and social situation of Sóller, it is not unthinkable that the phonological process described for this dialect displays incomplete unstressed vowel reduction or some gradient, more complex behavior.

2. METHOD

2.1. Speakers

Twelve male speakers participated in this experiment. The participants were between 19 and 26 years old, and they were bilingual in Catalan and Spanish, given that there are no longer monolingual speakers of Catalan on Majorca. Importantly, however, all of the speakers in the study were strongly Catalan-dominant; that is, the language the speakers use the most in their daily lives is Catalan.

The twelve subjects were evenly distributed by place of residence, and thus, regional sub-dialect of Majorcan Catalan. Six of them were born and raised in the village of Sóller, where they are currently residing, and the other six were born and raised (and continue to reside) in Palma, the capital city of Majorca, or its surrounding areas. The Palma speakers are taken to represent the general variety of Majorcan Catalan (and not only Palma). All of the participants had resided locally throughout their lives.

2.2. Materials

A total of 60 target words were devised for this experiment. The target word list consisted of 30 word pairs formed by disyllabic feminine nouns whose first vowel was a stressed /ɔ/, /o/ or /u/, and the derived diminutive forms of these same nouns (e.g., /ɔ/: *cosa-coseta* 'thing-little thing;' /o/: *copa-copeta* 'cup-little cup;' /u/: *puça-puceta* 'flea-little flea'). Crucially, diminutive formation in Catalan, by means of the suffix *-eta*, triggers systematic stress displacement from the stem to the suffix (e.g. *copa* [ˈkopə] - *copeta* [koˈpətə], 'cup-small cup'). Resorting to diminutive forms allowed us to control for lexical item, and thus for critical vowel phoneme, while rendering orthogonal control over the stress configuration of the (same) lexical root. The target words were controlled for vowel phonemes: 20 target words (10 base form-diminutive form pairings) per phoneme. Twenty filler pairs were also included in the design. They had the same structure as the target words, but had vowel phonemes other than /o/, /ɔ/ and /u/ as first vowel (e.g. *nina-nineta* [ˈninə]-[niˈnətə] 'girl-little girl').

Each target sentence included only one target word, which always appeared in sentence-medial position, as the direct object in a SVO + Adjunct sentence structure. The two forms of the lemma (base-diminutive) appeared embedded in the same carrier sentence. As many different carrier sentences as target lemmas were presented. For example, the blank in the carrier sentence *En Bernat menja _ cada vespre* 'Bernat eats _ every night' was filled once with the base form *sopa* [ˈsopə] 'soup' and once with the diminutive form *sopeta* [soˈpətə] 'little soup'.

2.3. Recordings

The speakers read a randomized list of sentences that was presented to them on a computer screen by means of PsychoPy2 [9]. Two iterations per target word were elicited from each speaker, which rendered a total of 1440 recorded vowel tokens (2 iterations $\times$ 60 target words $\times$ 12 subjects); 720 stressed vowels and 720 unstressed vowels.

The recording equipment was a condenser AKG C520 head-mounted microphone and a Sound Devices USBPre 2 audio interface (pre-amplifier + AD converter) connected to a laptop computer running Praat [2]. The speech signal was sampled at 44.1 kHz and 16-bit quantization. Eventually, 18 vowel tokens had to be excluded from the analyses because of either errors in production or recording deficiencies.

2.4. Acoustic Analyses

The difference between Catalan [o], [ɔ] and [u] is best captured by measuring vowel height [12, 13, 14]. Vowel height is assumed to be instantiated in the acoustic signal mostly by means of first formant (F1) frequencies. The present study follows recent research on Majorcan Catalan back vowels [15] in exclusively considering vowel height. (For an overview of the acoustics of Catalan vowels in several regional varieties of the language, see [12, 13]).

As first step in our analysis, the onset and offset of each vowel token were identified within the carrier sentence and marked manually. All boundaries were placed at upward zero-crossings in the sound wave.

Since target vowels could appear flanked by diverse consonant sounds, we relied on a number of context-dependent criteria in order to segment the acoustic data. (See [6] and [19]).

Acoustic data were extracted from three equidistant temporal landmarks corresponding to the first, second and third quartiles of the acoustic duration of the vowel token. Two values were extracted from each landmark: the fundamental ($f0$) and first formant (F1) frequencies. This produced a total of six values per vowel token (3 landmarks $\times$ 2 values). For each vowel token, the mean of the three $f0$ values, on the one hand, and that of the three F1 values, on the other, were adopted as the representative values for $f0$ and F1, respectively. (See [4] for a comparable procedure.)

The $f0$ data were extracted with the autocorrelation method with a pitch floor of 75 Hz and a pitch ceiling of 600 Hz. The F1 data were calculated from 25-millisecond Gaussian-window power spectra centered around each of the three temporal landmarks. In order to locate F1 on the spectra, we used the LPC method (Burg algorithm) as implemented in Praat [2].

The $f0$ and F1 means in Hz were then converted to Bark units [21, 17]. Subsequently, a height index was calculated, for each vowel token, by measuring the difference between the F1 and the $f0$ mean frequency values in Bark units. Similar techniques have been used in several studies ([15, 16, 18]). Henceforward, we will refer to our metric as *Height*.

3. RESULTS

The *Height* data were submitted as a dependent variable to a mixed-design (3) $\times$ (2) $\times$ 2 ANOVA with vowel *phoneme* (/ɔ/, /o/, /u/) and *stress configuration* (stressed, unstressed) as within-speaker factors and *dialect* (Palma, Sóller) as a between-speaker factor. The ANOVA revealed significant main effects of vowel phoneme ($F(2,20) = 482.7; p < 0.001$) and stress configuration ($F(1,10) = 163.3; p < 0.001$). The effects of dialect were not significant ($F(1,10) = 4.1; p > 0.05$). All two-way interactions were found to be significant: vowel $\times$ stress ($F(2,20) = 192.1; p < 0.001$), vowel $\times$ dialect ($F(2,20) = 17.4; p < 0.001$), and stress $\times$ dialect ($F(1,10) = 62.2; p < 0.001$). Most importantly, the ANOVA found a significant three-way interaction ($F(2,20) = 38.6; p < 0.001$). The mean *Height* values for the two groups of speakers as a function of vowel phoneme and stress configuration are shown in Table 1.

In order to explore the three-way interaction, the data were split into two subsets by dialect. Two by-speaker (3) $\times$ (2) repeated-measures ANOVAs, with vowel phoneme (/ɔ/, /o/, /u/) and stress configuration (stressed, unstressed) as within-speaker factors, were run to analyze the two subsets (Palma, Sóller) separately. Regarding the Palma data, the ANOVA revealed main effects of vowel phoneme ($F(2,10) = 211.1; p < 0.001$) and stress configuration ($F(1,5) = 12.06; p < 0.05$) as well as a significant interaction between the two factors ($F(2,10) = 31.07; p < 0.001$). This pattern was repeated in the second ANOVA, run on the Sóller data. The analysis showed significant main effects of vowel phoneme ($F(2,10) = 374.8; p < 0.001$) and stress configuration ($F(1,5) = 211.7; p < 0.001$), and a significant two-way interaction ($F(2,10) = 238.4; p < 0.001$). At this point, so as to determine how the three vowel phonemes are differently affected by stress in each of the two dialects (as revealed by the three-way interaction in the omnibus model), we further split the two data subsets by stress configuration.

Table 1: Mean vowel height (F1 [Bark] - $f0$ [Bark]) values as a function of dialect, vowel phoneme and stress configuration.

	Palma		Sóller	
Phon.	[+ str.]	[- str.]	[+ str.]	[- str.]
/ɔ/	4.13	3.41	4.27	2.36
/o/	3.31	3.31	3.21	2.35
/u/	2.36	2.35	2.23	2.29

Regarding the Palma data, a one-way repeated-measures ANOVA analyzed the potential effects of vowel phoneme (/ɔ/, /o/, /u/) exclusively for the *stressed* vowels. The model yielded significant main effects of vowel phoneme ($F(2,10) = 124.3; p < 0.001$). According to a series of paired t-tests (Bonferroni-corrected, α 0.05/3 = 0.016), all vowel phonemes differed from each other in stressed position: /ɔ/ *vs.* /o/ ($t(5) = 10.6; p < 0.001$), /ɔ/ *vs.* /u/ ($t(5) = 11.7; p < 0.001$), /o/ *vs.* /u/ ($t(5) = 9.9; p < 0.001$). A comparable ANOVA analyzed the *unstressed* vowels of Palma. The model rendered significant main effects of vowel phoneme ($F(2,10) = 194.1; p < 0.001$). A series of paired t-tests (α 0.05/3 = 0.016) showed that there were significant differences between /ɔ/ and /u/ ($t(5) = 15.6; p < 0.001$) and between /o/ and /u/ ($t(5) = 14.4; p < 0.001$). Crucially, though, there was no detected significant difference between the /ɔ/ and /o/ vowel phonemes in the unstressed condition ($t(5) = 2.8; p > 0.02$). All in all, the results indicate that the three vowel phonemes are phonetically different from each other in stressed position. However, this three-way contrast is reduced to two phonetic categories in unstressed position: the mid-low (/ɔ/) and mid-high (/o/) back vowels are merged into a single phonetic category ([o]), whereas high

vowels remain distinct in terms of height ([u]). This confirms prior phonological descriptions regarding the unstressed vowel reduction process that affects Palma (and other Majorcan varieties of) Catalan.

The Sóller data were also explored with two one-way repeated-measures ANOVAs, which analyzed the effects of vowel phoneme (/ɔ/, /o/, /u/) separately for stressed and unstressed vowel tokens. First, the model for the *stressed* vowels rendered significant main effects of vowel phoneme ($F(2, 10) = 346.4; p < 0.001$). As in the Palma data, Bonferroni-corrected paired t-tests (α 0.05/3 = 0.016) showed that all three vowel phonemes differed from each other in stressed position: /ɔ/ *vs.* /o/ ($t(5) = 20.23; p < 0.001$), /ɔ/ *vs.* /u/ ($t(5) = 20.77; p < 0.001$), /o/ *vs.* /u/ ($t(5) = 13.06; p < 0.001$). Most importantly, however, the ANOVA conducted on the *unstressed* vowel tokens revealed that these *did not* differ as a function of vowel phoneme ($F(2, 10) = 2.54; p > 0.1$). In sum, the statistical tests conducted on the Sóller data lead to the conclusion that stressed /ɔ/, /o/ and /u/ are produced as different phonetic categories ([ɔ], [o] and [u], respectively) only in stressed position. In unstressed position, on the other hand, the three vowel phonemes are merged into one single phonetic category. As readily observable in Table 1, the resulting phonetic category is [u]; unstressed /o/ and /ɔ/ "become" [u], while /u/ "stays" [u]. This also confirms prior dialectological descriptions of this regional sub-dialect of Majorcan Catalan, which were based exclusively on impressionistic observations.

4. DISCUSSION AND CONCLUSION

The purpose of the present study was twofold: First, we intended to test whether the traditional descriptions of the vowel systems of two Majorcan Catalan dialects, which were based on impressionistic observations, would be confirmed by an acoustic-phonetic investigation. Secondly, we wanted to verify whether the stress-induced vowel reduction patterns proposed by these descriptions were indeed implemented as full vowel mergers in unstressed positions or, on the contrary, could entail incomplete neutralization of vowel phonemes. The impressionistic accounts had described the vowel reduction processes in terms of phonological, categorical processes rather than gradient, phonetic phenomena [8, 11, 1]. Acoustic studies of vowel reduction processes in languages with unstressed vowel reduction not seemingly different from Catalan in this regard (i.e., Russian), however, had shown that vowel reduction phenomena may be gradient and thus not lead to full mergers [7]. The present study fundamentally confirmed the accuracy of traditional dialectological descriptions, and it provided evidence in favor of the categoricity of the vowel mergers caused by stress-induced vowel reduction in the two dialects under investigation.

Our research question was further motivated by the particular social situation that affects the two Majorcan dialects explored here. First, Majorcan Catalan, in spite of being an Eastern Catalan dialect, differs from all other Eastern varieties in its treatment of back-vowel unstressed vowel reduction. Second, Sóller Catalan, while being a variety of Majorcan Catalan, differs from the rest of Majorcan subdialects in its treatment of back-vowel unstressed vowel reduction. Since the two dialectal varieties find themselves in an intensive contact situation (see Introduction), it was not unexpected that they would somehow influence each other, even if asymmetrically.

It was determined, to begin with, that the variety of Majorcan Catalan spoken in the city of Palma (representative of the more general Majorcan Catalan pattern) has a phonological system with three back vowel phonemes that are produced as three distinct phonetic categories ([ɔ], [o], [u]) only in stressed position. The three phonemes merge into two phonetic categories in unstressed position: /ɔ/ and /o/ merge into [o] and /u/ is distinctly produced as [u]. Crucially, the acoustic analysis revealed that the /ɔ/-/o/ merger in unstressed position is complete in this dialect. Therefore, it was confirmed that /o/ shows a categorical change of vowel timbre as a function of stress, causing thus a phonological alternation for some *lemmas* (e.g. *roca-roqueta* [ˈrɔkə]-[roˈkətə] 'rock-little rock').

Sóller Catalan, on the other hand, was also found to produce the same three back vowel phonemes as three distinct phonetic categories ([ɔ], [o], [u]) in stressed position. In unstressed position, however, this variety exhibits a merger of the three phonemes to a single phonetic category, [u]. This three-way merger is complete in Sóller's regional dialect of Catalan, which confirms that the phonological alternations caused by vowel reduction in this subdialect (/ɔ/: *roca-roqueta* [ˈrɔkə]-[ruˈkətə] 'rock-little rock;' /o/: *copa-copeta* [ˈkopə]-[kuˈpətə] 'cup-little cup') can be accounted for in categorical terms. Now that these patterns have been established, at least one important question remains: What social factors allow for the pervasiveness of distinctive phonological features in a regional sub-variety of a language whose speakers find themselves in an intensive contact situation with speakers of neighboring dialects? This is left for a future study, but it is an important question in light of research on the diffusion of *koineization* processes across Europe [5].

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