AN ACOUSTIC STUDY OF SARDINIAN AND ALGHERESE CATALAN VOWELS

Submitted by
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Outline

Summary

The present dissertation sets out to instrumentally investigate the quality of the vowels of Algherese Catalan and of four Sardinian varieties, in order to pursue three different aims.

The **first aim** concerns the evaluation of the possible role played by Sardinian in modifying the quality of Algherese vowels. It is well known that the Sardinian city of Alghero still preserves its historical (i.e. Catalan) language, brought to the city by Catalan-speaking colonists in the second half of the fourteenth century and in the fifteenth century; during the centuries that followed, the Catalan origin population was entirely replaced by new immigrants from many areas of the Mediterranean and above all from the rest of Sardinia. This fact, along with the adstratum contacts maintained by the inhabitants of Alghero with the rest of Sardinia and with many Mediterranean port cities, contributed to the reshaping of the original dialect. In this process, a primary role has traditionally been attributed to Sardinian, and in particular to its Northern Logudorese variety, which is spoken in the territories and towns surrounding Alghero.

To fulfil the first aim of this dissertation, a formant analysis of the seven Algherese vowels /i, e, ɛ, a, ɔ, o, u/ in stressed position has been carried out for 525 realisations (7 vowels x 3 consonantal contexts x 5 repetitions x 5 native speakers), and the results have been compared to those obtained for 2,105 Sardinian realisations (7 vowels x 3 consonantal contexts x 5 repetitions x 5 native speakers x 4 varieties + 5 extra tokens). Also, as a framework of reference for Catalan, the corresponding data obtained by Recasens & Espinosa (2006) for the stressed vowels of four Catalan varieties have been included in the present work. A data normalisation method (i.e. CLIH, or Constant Logarithm Interval Hypothesis, proposed by Nearey, 1978) has also been applied to the formant data in order to better cope with individual differences due to the vocal anatomy of speakers, and also to better compare vowel formants across different dialects/languages.

As a result, the acoustic quality of Algherese vowels appeared to be more similar to that of Sardinian than to that of other Catalan varieties. In terms of individual dialects, as expected, the vowels most resembling those of Algherese were found to belong to the Northern Logudorese variety. These conclusions were also strongly supported by statistical analyses (ANOVA) of the formant frequency data. With regard to vowel duration, the three systems

under investigation, i.e. Sardinian, Algherese and the other Catalan varieties, turned out not to differ a great deal among themselves. Given the fact that Algherese still possesses the same seven vowel phonemes as Catalan, its vowel system was defined, according to the results obtained in the present study, as *phonologically Catalan and phonetically Sardinian.*

The **second aim** of the present work is to evaluate two predictions of the Adaptive Dispersion Theory against instrumental data from Algherese, Sardinian and other Catalan varieties. Specifically, the first prediction suggests that larger vowel inventories should cause the vowel space to expand, while the second suggests that vowels in more crowded inventories should vary less than vowels in less crowded ones. Both predictions are consistent, according to ADT, with the need to enhance perceptual contrast, and have been tested, with conflicting results, in many research studies over the last few decades.

The database for analysing these predictions was constituted by formant frequency values, both unnormalised and normalised (CLIH), which were obtained in order to fulfil the first aim of this dissertation.

The first prediction was tested by calculating the point-vowel area for each variety, both for unnormalised and normalised (CLIH) data. The results did not seem to confirm, in general, the validity of the ADT prediction for the dialectal varieties under investigation, since in various cases less crowded inventories (e.g. the pentaphonemic inventories of Nuorese and Common Logudorese) exhibited a larger point-vowel area than more crowded ones (e.g. the heptaphonemic inventories of Eastern Catalan, Western Catalan, Valencian and Campidanese, and the octaphonemic inventory of Majorcan), whereas an opposite outcome was predicted by ADT. When we tested the validity of the ADT prediction, the data also suggested the importance of taking into consideration such variables as the consonantal context surrounding the target vowels. In fact, as shown in the present study and also in other works from the literature (Recasens & Espinosa, 2006, 2009), the consonantal context may condition the realisation of stressed vowels, while affecting, in turn, the acoustic dispersion of the vowel system. To give an actual example from the data analysed in this work, the area encompassed by the Algherese vowels /i, u, a/ realised in a palatal consonant environment decreased by up to 50% compared to the area encompassed by the same vowels pronounced in a labial consonant context (182.620 Hz^2 and 271.025 Hz^2, respectively).

The second prediction of the ADT, namely, that there should be an inverse relationship between vowel system size and vowel variability, was tested by calculating the standard deviations of the mean contextual values for each vowel and each variety, and also across varieties. When the analysis was carried out for individual vowels among individual dialectal varieties, in some cases lesser variability was found for vowels belonging to more crowded inventories, but the opposite trend was also found. When the results were compared cross-dialectally, the Sardinian varieties, which have on average fewer vowel phonemes than the Catalan ones, showed less and not more context-dependent variability, thus challenging the ADT prediction in question. A further aspect which also seemed to challenge this prediction was that in some cases dialectal varieties possessing the same inventory size, such as Common Logudorese and Northern Logudorese, exhibited vowels which clearly differed among themselves in degree of context-dependent variability.

The **third aim** of this dissertation is to gather information on the acoustic reduction of Sardinian unstressed mid vowels. In this respect, some very interesting data published by Contini (1987:449) indicate that in three Sardinian varieties unstressed /ɛ, ɔ/ do not present, on average, visible signs of rising with respect to their stressed counterparts. This finding is in contrast with two models normally used to describe acoustic vowel reduction. The first, referred to in the present study as the undershoot-based model (UBM), predicts an overall elevation of the vowel floor due to enhanced coarticulatory effects associated with some specific conditions causing acoustic vowel reduction such as lack of stress and a shorter vowel duration. According to the second model, referred to as the centralisation-based model (CBM), similar contextual and prosodic conditions would cause instead a shift of the target vowels towards a central or 'schwa' region (Stetson, 1951, Van Bergem, 1993). The above mentioned results in Contini (1987) seem quite eccentric with respect to the predictions made by both UBM (at least in the formalisation proposed by Flemming, 2005) and CBM, since the unstressed open-mid vowels did not show any visible traces of elevation.

In order to gather more data on this issue, a further set of 1,215 unstressed vowels was analysed (12 vowels x 5 repetitions x 5 informants x 4 Sardinian dialects[1]), including samples of both Sardinian unstressed open-mid and close-mid vowels; also, samples of the same

[1] The final number of the analysed vowels was slightly lower than the expected, since a small group of them were unfit for the formant measurements.

vowels were recorded and analysed in pretonic (AT-1), pre-pretonic (AT-2) and, for Campidanese, pre-pre-pretonic (AT-3) position.

The analysis results confirmed the finding by Contini that, in contrast with the predictions of both CBM and UBM, Sardinian open-mid vowels lack visible rising. Interestingly enough, in the same variety close-mid vowels did seem to undergo a certain process of lowering. A further investigation into individual productions showed that in some cases (in around 5% of the total realisations) some expected close-mid vowels were instead pronounced as open-mid, and in some very rare cases (four tokens in total) some expected open-mid vowels were realised as close-mid. On the one hand this rather unexpected outcome was considered in the study to have possibly contributed to an average F1 increase of unstressed [e] and [o]. On the other, a new theoretical approach was needed in order to better understand why 'jumps' from (expected) [e, o] to [ɛ, ɔ] occurred 3.6 times more often than 'jumps' from [ɛ, ɔ] to [e, o]. Also, a different approach was required to understand why the 'jumps' in question were considerably more frequent in pre-pretonic position (9.6% of the realisations of [e, o]) than in pretonic position (3.6%). Based on other studies from the literature, it was hypothesised that Sardinian close-mid unstressed vowels would be less stable (and would thus present more 'jumps') than the corresponding open-mid vowels due to 'language-dependent factors'. This should be so since, while the realisation of Sardinian open-mid vowels is conditioned by just an opening pressure (i.e., Sardinian mid vowels are naturally pronounced as open-mid unless metaphony occurs), Sardinian close-mid vowels are affected by two opposite pressures: the natural tendency for mid vowels to be uttered as open-mid and the closing pressure induced by metaphony. The metaphonic pressure, which affects almost systematically stressed mid vowels directly followed by a close or close-mid vowel, was seen not to be always able to overwhelm the natural opening pressure of Sardinian mid vowels when the latter occur in unstressed position, and especially when they are distant from the stressed vowel. These and other kinds of data led us to conclude that when evaluating acoustic vowel reduction in Sardinian mid vowels it is important to take into account language-dependent or *systemic* variables (among others).

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a tie
chi mi daisti sa manu
e la mantennisti
pro una vida intrea

Chapter 1

The Algherese stressed vowel system between its Catalan origin and possible later Sardinian influence

Chapter 1 introduces the first aim of the present dissertation, namely the evaluation of the possibility that immigrants to Alghero, particularly those from other parts of Sardinia, have over the centuries modified the Catalan origin quality of Algherese vowels. Sections 1.1 to 1.3 include a brief introduction to Algherese, Sardinian and other Catalan varieties. Section 1.4 contains information about the historical repopulation of the city. The possible influence on Algherese of Sardinian and other languages is dealt with in section 1.5. Sections 1.6.1 and 1.6.2 are devoted to the investigation of the mechanisms that can allow immigrants to acquire a native-like pronunciation of an L2 or, by contrast, to prevent them from achieving complete mastery in the new language. In section 1.6.3 all the information discussed in the previous sections is used to make predictions about the possible role played by historical immigration (mainly Sardinian) to the city in acoustically modifying Algherese vowels.

1.1 Brief introduction to Algherese Catalan

The city of Alghero, in north-west Sardinia, still preserves its own historical language, a variety of Catalan called Algherese. Its origins date back roughly to the second half of the fourteenth century, during the 90-year campaign waged by the Crown of Aragon to invade Sardinia. In 1353 the Catalan-Aragonese army conquered the stronghold of Alghero, then held by the powerful Doria family of Genoa, for the first time, but after their fleet went back to the Iberian peninsula, the original inhabitants (mainly Sardinians and Genoese) managed to regain control of the city by slaughtering the garrison left there by the invaders.[2] In 1354 Alghero was besieged again for months, until a political agreement was reached between the Crown of Aragon and the *Judike*[3] Mariano de Arborea, the most powerful Sardinian ruler of the time, under which the besiegers were finally able to enter the stronghold and, in order to avoid possible future rebellions, repopulate it with Iberian (namely Catalan-speaking) colonists and soldiers.[4]

[2] See Budruni, 2010, Chapter IV.
[3] The title of *Judike* refers to the ancient Sardinian kings.
[4] See Budruni, 2010, Chapter IV.

How many people speak Algherese today? In a recent sociolinguistic survey commissioned by the Sardinian Regional Government (*Le Lingue dei Sardi*, henceforth LDS),[5] 50% of the interviewees declared an active oral competence in this Catalan variety, a figure not far from the 20,000 speakers hypothesised by Veny (1982/2002:74). According to another sociolinguistic survey, commissioned by the Generalitat de Catalunya[6] (i.e. *Enquesta d'usos lingüístics a l'Alguer 2004*, henceforth EULA), the percentage of people declaring an active oral competence in Algherese was 61.3% in 2004.[7] Rather different figures are reported by Caria (2006:36), for whom 'el nombre general d'usuaris de l'alguerès'[8] accounts for 17.8% (roughly 7000 people).

The differences in the results probably spring from the different methods used to gather the data. In fact, both LDS and EULA were exclusively carried out in Italian, and the degree of linguistic competence in Algherese (and also in other languages spoken in Sardinia, in the case of LDS) was reckoned on the basis of the self-assessment of the informants. By contrast, the study by Caria could undoubtedly count on the native competence of the author in appraising the percentual number of speakers of Algherese, but no information is reported in his study with regard to the method used in gathering and analysing the data.

Another problem concerning the correct evaluation of the number of Algherese Catalan speakers is, as pointed out in another work by the author of the present study,[9] that the use of dichotomic parameters in order to strictly classify *active* vs. *passive* competence or vs. *no competence* at all can be highly problematic in the case of Algherese, since many degrees of active oral competence can be found among, for example, young speakers.

All things considered, until a survey including both quantitative and qualitative data is undertaken, it would probably be more prudent not to give definite figures for people possessing a native active oral competence in Algherese, a number which can be roughly calculated as 'a few thousands', although this figure increases if we include such categories as 'almost-native speakers', 'sporadic speakers' (for example, people who only use Algherese with elderly people or with Catalan tourists), and so on.

[5] See Oppo et al., 2007, Table 8.3.
[6] See EULA, 2004.
[7] *Ibid.*, Table 1.6.
[8] 'The general number of users of Algherese'.
[9] See Ballone, 2012b.

From a dialectological point of view, Algherese Catalan is traditionally placed among the Eastern Catalan varieties, owing to specific linguistic features such as the presence of the phenomenon of *total* phonological vowel reduction.[10] However, this view (i.e. the exclusive inclusion of Algherese among Eastern varieties) has been challenged in recent works, such as Corbera (1995):

> En definitiva, si és veritat que, del punt de vista del sistema fonològic, sobretot el de les vocals, l'alguerès pot anar de costat dels dialectes del grup designat com a 'oriental', també és veritat que, respecte al lèxic, l'alguerès és especialment singular i característic, no associable a cap altre dialecte, ni insular ni continental, amb una presència relativament important de termes propis tant dels parlars orientals com dels parlars occidentals, encara que amb un lleuger predomini d'aquells.[11]

Caria (1990:35-36) also proposes a different framing for Algherese, considered by him not to be totally classifiable as an Eastern dialect but rather an *eclectic* or intermediate variety in the Catalan system.

It could be useful at this point to discuss the position of Algherese vis-à-vis Eastern and Western Catalan varieties on the basis of specific linguistic features concerning historical phonetics, morphology and lexicon. In order to do this, Table 1 shows in the first two columns the most important linguistic characteristics of the Eastern and Western varieties according to Veny (1982/2002:19-20), [12] followed, in the rightmost column, by the corresponding characteristics of Algherese.

[10] The phenomenon of *total* phonological vowel reduction is intended here, with specific reference to Catalan dialectology, as the change of stressed /ɛ/ and /e/ into [ə] (or into [a] in Algherese and some sections of the population in the Barcelona area), and of stressed /ɔ/ and /o/ into [u], in the unstressed domain.

[11] 'In sum, even though it is true that, from the point of view of the phonological system, above all as regards vowels, Algherese seems to be close to the group defined as 'Eastern', it is nonetheless true that, as regards the lexicon, Algherese presents its own characteristics and is not comparable to any other [Catalan] dialect, either insular or continental, with a relatively significant presence of words specific to both Eastern and Western varieties, even though the former are slightly more represented' (Corbera, 1995:11).

[12] In translating from the original Catalan version into English, some adaptations were made, mostly regarding the phonetic transcription of linguistic sounds following IPA guidelines. A copy of the original scheme by Veny, 1982/2002 is given in Appendix II.

	Eastern varieties	Western varieties	Algherese	
		A) Historical Phonetics		
1	unstressed A, E → [ə] (total phonological vowel reduction)[13]	unstressed A, E still distinct (partial phonological vowel reduction)	unstressed A, E → [a] (total phonological vowel reduction)	East.
2	unstressed O, U → [u] (total phonological vowel reduction)	unstressed O, U still distinct (partial phonological vowel reduction)	unstressed O, U → [u] (total phonological vowel reduction)	East.
3	mid high Ē vulgar Lat. > /ɛ/: CEPA> 'c[ɛ]ba'	mid high Ē vulgar Lat. > /e/: CEPA> 'c[e]ba'	'c[e]ba'[14]	West.
4	short Ŭ of JŬNCU→ [o]	short Ŭ of JŬNCU→ [u]	short Ŭ of JŬNCU→ [o]	East.
5	stressed GUÁ-, QUÁ- normally [ko], [go]: 'cotre' (quatre); 'gotlla' (guatlla)	stressed GUÁ-, QUÁ- are normally preserved: 'quatre'; 'guatlla'	'quatre'	West.
6	final -GUA (or -QUA) normally [gə] (or [kə]): 'aig[ə]' ('aigua') 'lleng[ə]' ('llengua')	final -GUA (or -QUA) normally preserved: 'aigua', 'llengua'	'aigua', 'llengua'	West.
7	vulg.Lat. LY, C'L, G'L > [j]: PALEA> 'pa[j]a', OC'LU > 'u[j]'	vulg.Lat. LY, C'L, G'L >[ʎ]: 'pa[ʎ]a', 'u[ʎ]'	'pa[ʎ]a', 'u[l]' / 'u[ʎ]ada'	West.
8	initial or postconsonantal [ʃ]: '[ʃ]in[ʃ]a', 'pan[ʃ]a'	initial or postconsonantal [ʧ]: '[ʧ]in[ʧ]a', 'pan[ʧ]a'	'[ʧ]in[ʧ]a', 'pan[ʧ]a', but '[ʃ]aloc'	East. West.
9	intervocalic or final [ʃ] not preceded by [j]: ['kaʃə] ('caixa'), [koʃ] ('coix')	intervocalic or final [ʃ] keeping traces of [j]:[15] ['kajʃa] ('caixa'), [kojʃ][16] ('coix')	'ca[ʃ]a'	East.
10	dental insertion after words ending in 'r': 'cor[t]' ('cor'), 'car[t]' ('car')	lack of this kind of epithesis: 'cor', 'car'	'cor'	West.
11	no nasal epenthesis in 'llagosta'	nasal epenthesis in 'llangosta'	'llagosta'	East.
12	HEDERA > 'heura'	HEDERA > 'hedra'	'hèdera'	Algh.

[13] For a typological list of exceptions to phonological vowel reduction in Eastern Catalan varieties and Algherese, see Mascaró, 2002 and Ballone, 2008, respectively.
[14] It should be noted that, in parallel to the Western and Eastern Catalan varieties, Algherese speakers pronounce Latin Ē as open-mid in words such as 'tela' ('canvas') and 'vel' ('veil').
[15] The original text probably contains a typing error, since it states '*no precedida de iod*' ('no preceded by [j]'), which would make the West. pronunciation of 'caixa' identical to that of its East. correspondent.
[16] In the original version, ['kaĭʃa] and [koĭʃ].

		B) Morphology		
13	plural forms of ancient proparoxytone words ending in ‘n’ have lost the nasal: ‘home/homes’	plural forms of ancient proparoxytone words ending in ‘n’ have kept the nasal: ‘home/hòmens’	‘hòmens’, but ‘joves’	East. West.
14	ending [u], [i] or ø in the pers. 1 of the pres. simple: ‘cant[u]’, ‘cant[i]’, ‘cant’	ending [o] or [e] in the pers. 1 of the pres. simple: ‘cant[o]’, ‘cant[e]’	‘cant’	East.
15	‘reinforced’ and/or ‘reduced’ forms of weak (i.e. unstressed) personal pronouns: ‘em, ens, et, us, el, els, en’	‘full’ form of unstressed personal pronouns: ‘me, mos, te, vos, se (lo), (los), ne’	‘me, mos (nos), te, vos, se, lo, los, ne’	West.
16	ending [e] of pres. simple and subjunctive (pers. 1, 2, 3, 6) and of imperative (pers. 2) of inchoative verbs: ‘serv**e**ix’, ‘serv**e**ixi’, ‘serv**e**sca’	ending [i] of pres. simple and subjunctive (pers. 1, 2, 3, 6) and of imperative (pers. 2) of inchoative verbs: ‘serv**i**x’, ‘serv**i**sca’, ‘serv**i**xa’	‘serv**e**ix’, ‘serv**e**ixi’	East.
17	ending of pers. 1, 2, 3, 6 of subjunctive present tense: ‘-i’, ‘-is’, ‘-i’, ‘-in’, respectively	ending of pers. 1, 2, 3, 6 of subjunctive present tense: ‘-a’, ‘-es’, ‘-e’, ‘-en’, respectively	‘canti’, ‘cantis’, etc.	East.
		C) Lexicon		
18	dialect-specific lexicon: a) ‘mirall’; b) ‘noi’; c) ‘llombrígol’; d) ‘xai’, ‘be’	dialect-specific lexicon: a) ‘espill’; b) ‘xic’; c) ‘melic’; d) ‘corder’	typical Eastern and Western lexicon; also, specific Algherese lexicon	East. West. Algh.

Table 1: Summary of the main characteristics of the Eastern and Western Catalan dialectal varieties adapted from Veny, 1982/2002:19-20 (first and second left columns, respectively). In the third column the correspondent outcomes of Algherese have been added. The abbreviations in the rightmost column indicate that the Algherese outcome is more similar to the corresponding outcome in the Eastern varieties (East.) or the Western varieties (West.), or that it is specific to the Algherese dialect (Algh.).

The rightmost column of the table indicates that Algh. shares linguistic features with both Eastern and Western varieties: in eight cases with the former (points 1, 2, 4, 9, 11, 14, 16, 17), in six cases with the latter (points 3, 5, 6, 7, 10, 15), and in three cases with both (points 8, 13,

18).[17] The interdialectal analysis in Table 1 has been carried out in terms of binary 0/1 comparisons of individual phonetic, morphological and lexical features, and could be further developed by adding, among other things, quantitative and qualitative information on the greater importance and visibility of certain phenomena compared to others. For instance, points 1 and 2 concern a phenomenon (phonological vowel reduction) which is much more frequent in spoken Catalan than, for example, the realisation of the specific word dealt with in point 12. Developing this level of analysis further, however, would bring us far from the scope of the present work, and it will be sufficient here to state that, all in all, the definition given by Caria of Algherese as an intermediate variety in the Catalan diasystem may be not unfounded, even though, as will be made more clear in the next two sections, Algherese has a specific history among all the Catalan varieties by virtue of having been much influenced by Sardinian and certain Italian dialects, and, more recently, by (standard) Italian.

1.2 Sardinian

Sardinian is a Romance language spoken in the island of Sardinia, situated in the western basin of the Mediterranean Sea, and is considered by many scholars to be 'the most conservative of the Romance languages'.[18]

In the survey *Le lingue dei Sardi* (LDS) a considerable majority of the interviewees living in Sardinian-speaking areas[19] claimed to possess an active competence in Sardinian, ranging between the 76% of subjects living in the Logudorese-speaking areas and the 68.9% of those living in the Campidanese-speaking ones. As regards oral *passive* competence, Sardinian is claimed to be understood by almost all the interviewees living in these same areas.[20]

On the other hand, LDS shows that there is an unbalanced relationship, on the island, between Italian and Sardinian, the latter being usually described as suffering diglossia in favour of the former. In fact, data displayed throughout the report suggest that many Sardinian

[17] The total number of examples dealt with in this brief analysis is 17. The missing eighteenth point is number 12 in the table, which concerns a phytonym presenting a specific pronunciation in Algherese and was consequently included in the category of point 18. Some additions were made to the scheme for Algh. by the author of the present study, such as in points 8 and 13, to suggest that further levels of comparative analysis are also possible, and also that, for some specific sets of words, it cannot be stated that Algherese exclusively follows the pronunciation patterns of either Western varieties ('joves') or Eastern varieties ('hòmens', with the etymological nasal).

[18] This definition is given by Jones, 1988:314. For a different view see Bolognesi, 2005, especially pages 55–64.

[19] In other words, Sardinian people not living in Alghero, Carloforte, Calasetta, Gallura and the Sassari area, where non-Sardinian based languages are spoken.

[20] The percentages of subjects who claimed not to have either active or passive competence in Sardinian were 2.1% for the Logudorese and 3.4% for the Campidanese areas.

speakers prefer using their mother tongue in informal rather than formal contexts, and in family and with friends rather than with strangers. Social pressure disfavouring the normal use of Sardinian seems to be even stronger if figures regarding the interruption of intergenerational transmission are taken into consideration; in fact, 74.2% of interviewees aged between 25 and 44 claimed to only use Italian to talk to their sons and daughters.[21]

In 1997 Sardinian was attributed, alongside Italian, the status of official language of the island by the Regione Sardegna. Two years later the Italian government issued Legge 482/1999 on *Norme in materia di tutela delle minoranze linguistiche storiche*, giving some regional governments the possibility to introduce their historic languages into many areas of the public sector[22] and education. Nowadays the Sardinian regional government uses a standard written variety of Sardinian, known as *Limba Sarda Comuna*,[23] to produce some of its official documents.

As regards the dialectal division of Sardinian, many classifications are possible, according to the individual isoglosses which may be taken into account for specific purposes. A more general partition can probably be made between Campidanese, spoken in the centre-south of the island (except for the Ligurian-speaking towns of Carloforte and Calasetta, on the south-west coast), and Logudorese, spoken in the centre-north of Sardinia, with the exception of the northernmost regions and the city of Alghero, where, respectively, Gallurese, Sassarese and Algherese Catalan are spoken.[24] This first general division of Sardinian into just two macro varieties is of course arbitrary and has traditionally been used by scholars as a simply heuristic classification, since many other subdivisions can be made.

In general terms, the three main linguistic features normally used to distinguish Logudorese from Campidanese are: the plural of the definite article *sos*/*sas* (Logudorese) vs. *is* (Campidanese); the conservation in the former variety of velar /k/[25] before front vowels (e.g. Latin CENTUM > ['kentu] 'hundred' vs. Campidanese ['ʧentu]); and the process of phonological vowel reduction, by which final /ɛ/ and /ɔ/ become, respectively, [i] and [u] in

[21] LDS, Table 2.5. In this case the figures represent data across the whole island, including both Sardinian-speaking areas and areas where other historic languages are spoken.
[22] With the exception of the armed forces and the police.
[23] See http://www.regione.sardegna.it/documenti/1_72_20060418160308.pdf or search for 'Limba sarda comuna' in an online search engine.
[24] According to LDS, many inhabitants living in those areas also possess an active oral competence in Sardinian.
[25] It should be added that the voiceless velar stop may undergo a dialect-dependent voicing process in intervocalic position, as described in Wagner, 1941/1984:118–124 and Jones, 1988:318–322.

Campidanese but not in Logudorese (for example, the Logudorese words [ˈpanɛ] ‘bread’, and [ˈdɔmɔ] ‘house’, are pronounced as [ˈpani] and [ˈdɔmːu] in Campidanese). This latter process, along with a partial application of Sardinian vowel metaphony in the two dialectal varieties, has led Campidanese to show a richer phonemic vowel inventory than Logudorese, with seven and five vowel phonemes, respectively, as will be further explained in § 2.3.

As anticipated above, numerous other isoglosses can also be found to create further dialectal divisions in Sardinian. Virdis (1978), for example, identifies at least eight subvarieties of Campidanese, while Contini (1987b, tables 110-114) suggests that many dialectal differences can also be found across the centre-northern regions of the island. However, for the purposes of the present study (i.e. for the choice of the areas to be investigated) and as shown in Figs. 1 and 2, Sardinian has been divided into only two macro varieties, i.e. Campidanese and Logudorese, and Logudorese has been further subdivided into the three varieties known as Common Logudorese, Nuorese and Northern Logudorese.

The most general division within the Logudorese macro variety could be set between, on the one hand, the Nuorese (or central) variety, spoken in the mountainous areas of the centre-east of Sardinia, and, on the other, Proper Logudorese, spoken towards the centre-west and the north of the island. Nuorese is composed of a group of dialects which seem far from homogeneous, as some of Contini’s tables show, although they do share some common features, such as a greater tendency than Proper Logudorese dialects to conserving the intervocalic voiceless plosives (see, *inter alia*, Table 3 in Contini 1987b, with Proper Logudorese [ˈkuβa]/ [ˈkuba] ‘barrel’ vs. Nuorese [ˈkupa]), particularly towards the region of Baronie. The characterisation given here of this set of dialects as Nuorese (used by, among others, Campus, 1901 and Jones, 1988) does not strictly refer to the Sardinian variety spoken in the city of Nuoro, as much as it is intended to cover an area reaching the Baronie to the north, the Barbagia of Ollollai to the south, and the town of Ottana to the west.

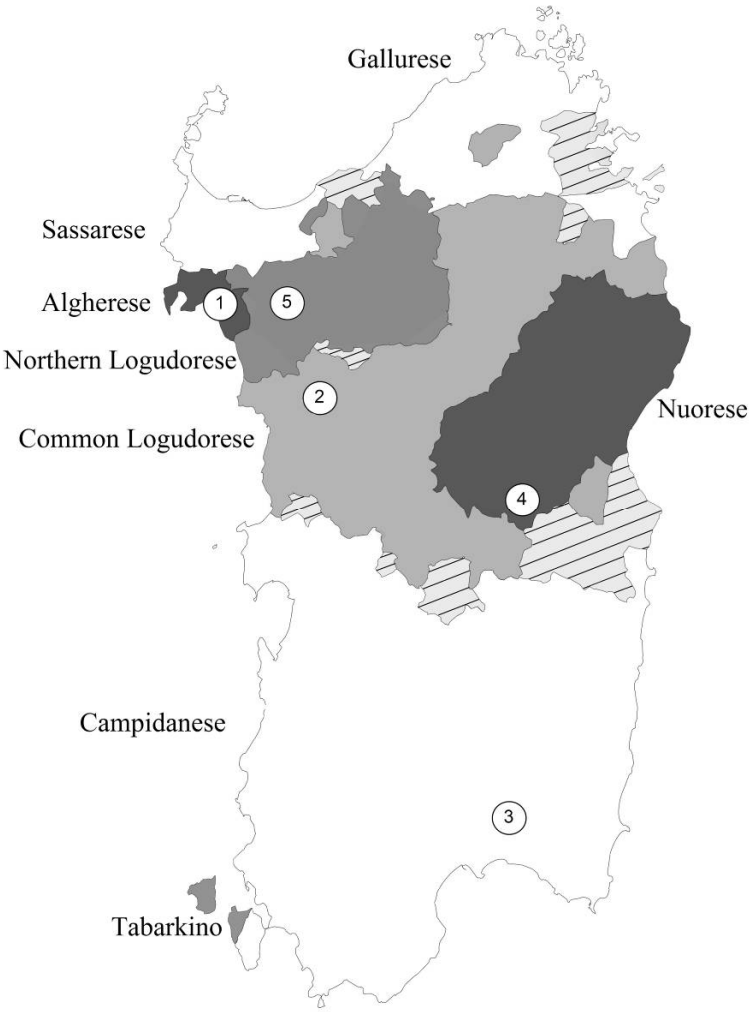


Figure 1: Sardinian dialect map. Numbers 1 to 5 indicate the points of survey included in the present work, i.e. Alghero (1), Pozzomaggiore (2), Sinnai (3), Fonni (4), Ittiri (5). The criteria used to draw dialect boundaries in the map are explained in detail in Appendix I.

The second further dialectal division taken into account in the present study is internal to the variety referred to here as Proper Logudorese. In fact, following Campus (1901, particularly pages 12-15), two specific Proper Logudorese types can be distinguished on the basis of the presence or absence of certain fricative sounds, such as [ɬ]. The type including [ɬ] will be referred to in this study as Northern Logudorese, and its boundaries will be defined here as per Table 56 by Contini (1987b), with the exclusion of the Sassarese-speaking area.[26] The other type will be referred to as Common Logudorese. The tree diagram of the Sardinian dialectal taxonomy used in the present work is summed up in Fig. 2.

[26] The sound [ɬ] is both shared by the Northern Logudorese and Sassarese varieties. Readers who are not acquainted with the borders dividing Logudorese and Sassarese can consult Table 55 in Contini, 1987b; in this table the north-western areas left blank are exactly the ones where Sassarese is spoken, and do not exhibit the Sardinian plural definite article 'sos, sas'. The dialect of Giave is said to present the sound [ɬ], though in alternation with [l].

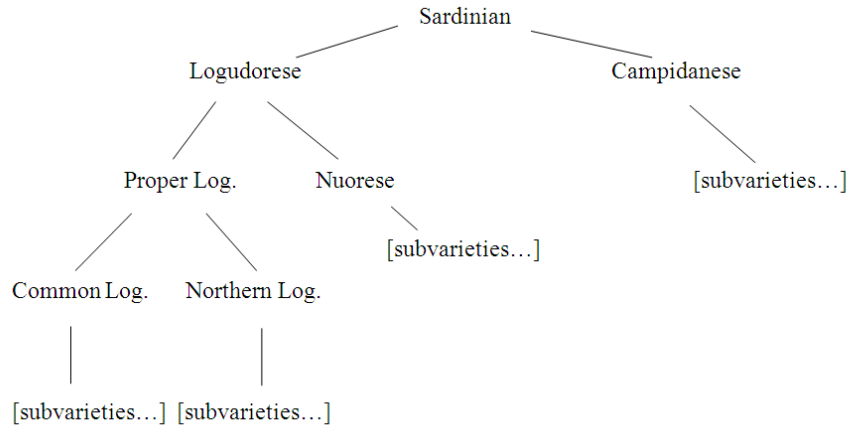


Figure 2: Tree diagram of the Sardinian dialectal taxonomy used in the present study.

1.3 Catalan

Catalan is a Romance language spoken on the east coast of the Iberian peninsula and across the eastern Pyrenees, reaching northwards into so-called French Catalonia. It is also spoken in the Balearic islands, in the Sardinian city of Alghero and in the Principality of Andorra.

According to recent surveys [27] promoted by the Generalitat de Catalunya, nine million people have an active oral competence in Catalan, while another two million possess a passive oral competence in the language. Catalan is spoken in three states of the European Union (Spain, Italy and France), and in the Principality of Andorra, and is probably the largest non-official language in Europe.

With the advent of democracy in Spain, Catalan acquired the status of co-official language along with Spanish in Catalonia, the Valencia region and the Balearic islands. In those autonomous communities, Catalan is present in the education system, in the mass media and in the public sector, though with considerable differences from one autonomous community to another.[28] Detailed analysis of these preliminary sociolinguistic considerations goes beyond the aims of the present study, but it is worth mentioning the fact that Catalan, too, suffers from some of the problems shared by other minority languages in Europe. For example, survey data gathered in Catalonia suggest that Spanish is still the first language acquired by

[27] See Querol (coord.), 2007.
[28] For those who want to know more about these aspects for each Catalan-speaking territory, further information is available in Pradilla Cardona, 2012; Montoya Abat, 2012; Melià, 2012; Sistac, 2012; Baylac & Deixona, 2012; Ballone, 2012; Torres-Pla, 2012.

the majority (56.7%) of its inhabitants, whereas (only) 35.3% of Catalan residents have Catalan as their first acquired language,[29] a fact largely due to historic and recent immigration from Spanish-speaking territories. Part of these newcomers have integrated themselves – also linguistically – into Catalan society, which is why the number of people declaring Catalan as their language of identification is higher (39.4%)[30] than the figure indicating the number of people having Catalan as their first acquired language (35.3%). If, on the one hand, Catalan is still far from being considered the language of identification for the majority of the inhabitants of Catalonia, it is nonetheless true that the efforts of Catalan society and its institutions have made it possible for more than three quarters of the population (77.5%) to have an active oral competence in the language.

In the Comunitat Valenciana the number of people with an active oral competence in Catalan has decreased over the last few decades to (roughly) 50% of the entire population,[31] and a similar trend, though in a less apparent way, is also present in the Balearic islands, where the active oral competence of residents has shifted from 71% in 1986 to 63% in 2010.[32] However, as seen above for the Catalonia region, these data do not necessarily suggest that Catalan speakers tend to abandon their mother tongue; in fact, the relative decrease in active oral competence among the total residents is partially due to historic and recent non-Catalan-speaking immigration. In the case of the Balearic islands, for example, in 2011 the percentage of residents who were actually born in that autonomous community was (just) 58.4%,[33] and in this respect the 63% of people who have an active oral competence in Balearic Catalan is not a figure to be underestimated.

One possible general classification of Catalan varieties can be made through differentiation between *constitutive* and *consecutive* dialects.[34] It is known that Romance languages are the result of the interaction of Latin (in its diverse diatopic, diachronic and diastratic variation) and the pre-Latin languages spoken in the different regions touched by Roman expansion.[35] From our perspective, it is important to point out that this interaction mainly took place *in loco*, and even in areas like the Italian peninsula, which was geographically adjacent to the

[29] See Pradilla Cardona, 2012:23.
[30] *Ibid*.
[31] See Montoya Abat, 2012, Fig. 1.
[32] See Melià, 2012:34.
[33] *Ibid*., p. 33.
[34] See Veny, 1982/2002:17.
[35] See, among others, Harris, 1988.

core of the empire, the intense presence of Latin over the centuries did not prevent local populations from speaking local varieties of Latin and later developing quite differentiated Romance idioms. It is not by chance that the modern tendency to uniformity or standardisation does not come from a natural evolution of local languages, as much as it is mainly the result of the spreading of a particular dialect across the entire territory of a given state, or empire, and so on.[36]

Other Romance languages have, like Spanish and Catalan, modern standard reference varieties, but when it comes to their internal diatopic variation, this seems not to be as apparent as the variation present, to mention just one example, across the Italian peninsula. This higher level of uniformity (or lower level of variation) is said to be mainly due[37] to the Arab occupation of the southern and central areas of the Iberian peninsula, an occupation which somehow 'compressed' northwards the new-born Romance languages present in those territories (see Fig. 3).

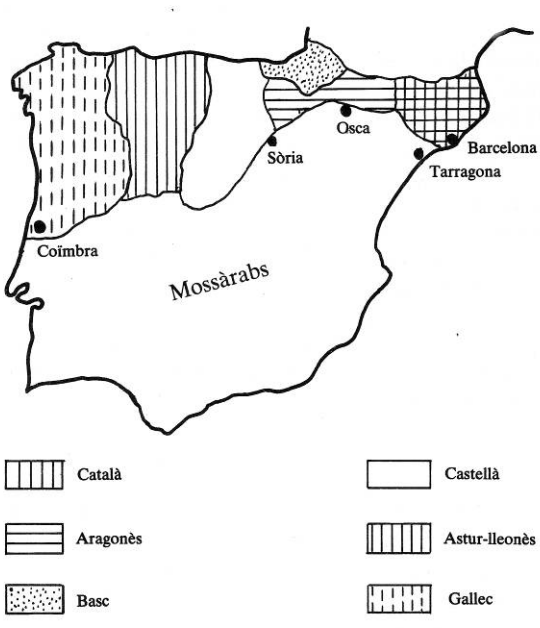


Figure 3: Linguistic map of the 'compressed' Iberian languages before the 'Reconquesta' carried out by Christian kingdoms (extracted from Entwistle, 1936/1968 via Veny, 1982/2002:15).

[36] See Harris, 1988b:209 for French; Marazzini, 2002 for Italian; Mallinson, 1988:391 for Romanian.
[37] See Entwistle, 1936/1968 and Veny, 1982/2002:16.

After this period of 'compression', which lasted for a few centuries and presumably caused the various dialects of each language to somehow reduce their differences, the Christian kingdoms spread southwards, in consistence to their progressive victories against the caliphates, and, in so doing, Christian colonisers repopulated the south of the Iberian peninsula and the Balearic islands.

This brief historic introduction was necessary to understand a first important taxonomy used to differentiate between *constitutive* Catalan dialects, i.e. those directly developed from the Latin variety spoken in a given territory, and *consecutive* ones, i.e. those resulting from the repopulation by Catalan-speaking colonists after the Reconquesta[38] and (in the case of Alghero) further military campaigns. The constitutive dialects are the ones spoken in the centre-north areas of the present-day Catalonia region and those of *Catalunya Nord* or French Catalonia, in the Roussillon region, while the consecutive ones are those spoken in the Valencia region, in the Balearic islands and in the city of Alghero.

From a merely spatial point of view, a generally accepted partition is the division between Eastern and Western varieties proposed by Milà i Fontanals in 1861[39] and further developed by other authors (see Fig. 4).

[38] See Veny, 1982/2002:19–20.
[39] See Milà Fontanals, 1861:461–463.

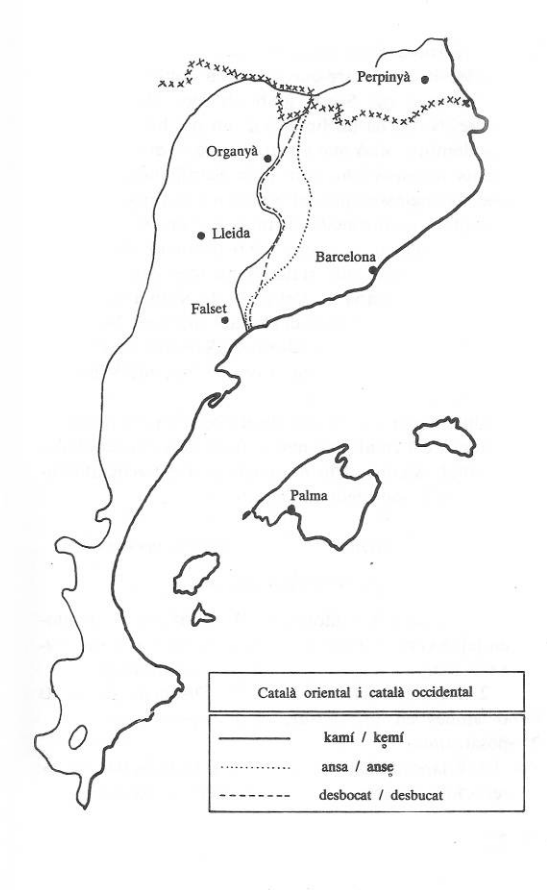


Figure 4: Linguistic map of the Western and Eastern Catalan varieties (extracted from Veny, 1982/2002:18).

A list of the main differences between the Western and Eastern varieties of Catalan has been proposed by Veny, 1982/2002:19–20 (see Table 1 and Appendix II in the present study). In the Eastern varieties, for example, unstressed 'e' and 'a' are normally realised as [ə] (and as [a] in Algherese and some sections of the population in the Barcelona area), and 'o' and 'u' as [u] (with some exceptions, as anticipated above in footnote 13). This phenomenon, known as phonological vowel reduction, is also present in Western varieties, though in a *partial* way, in that the stressed open-mid vowel phonemes /ɛ, ɔ/ are normally reduced to their close-mid cognates [e, o] in unstressed position, but they do not become, respectively, [ə, a] and [u], as happens instead in Eastern varieties,[40] which are said to present a *total* phonological vowel reduction.

[40] For a detailed description of phonological vowel reduction across Catalan varieties, see Mascaró, 2002.

Fig. 5 presents the traditional diatopic classification of Catalan varieties, while Fig. 6 shows the relationships between the same dialects.[41]

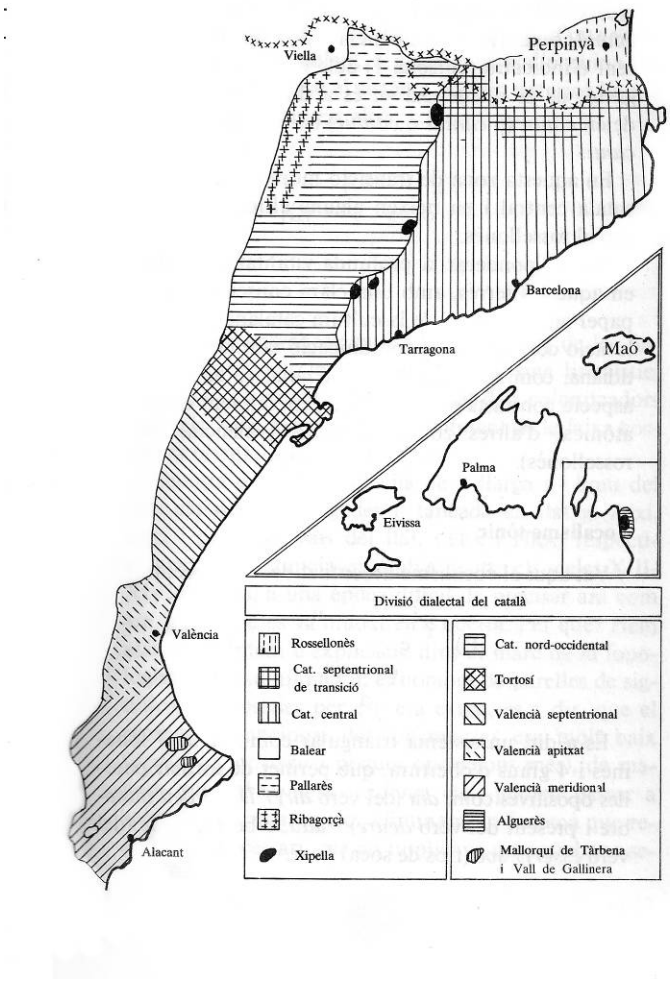


Figure 5: Linguistic map of the Catalan dialects (extracted from Veny, 1982/2002:27).

[41] This division might present some differences in the view of some authors (see, *inter alia*, Recasens, 1991). As regards the totally Eastern filiation of Algherese Catalan, some doubts are expressed (as seen above in § 1.1) by Caria (1995) and Corbera (1995), among others.

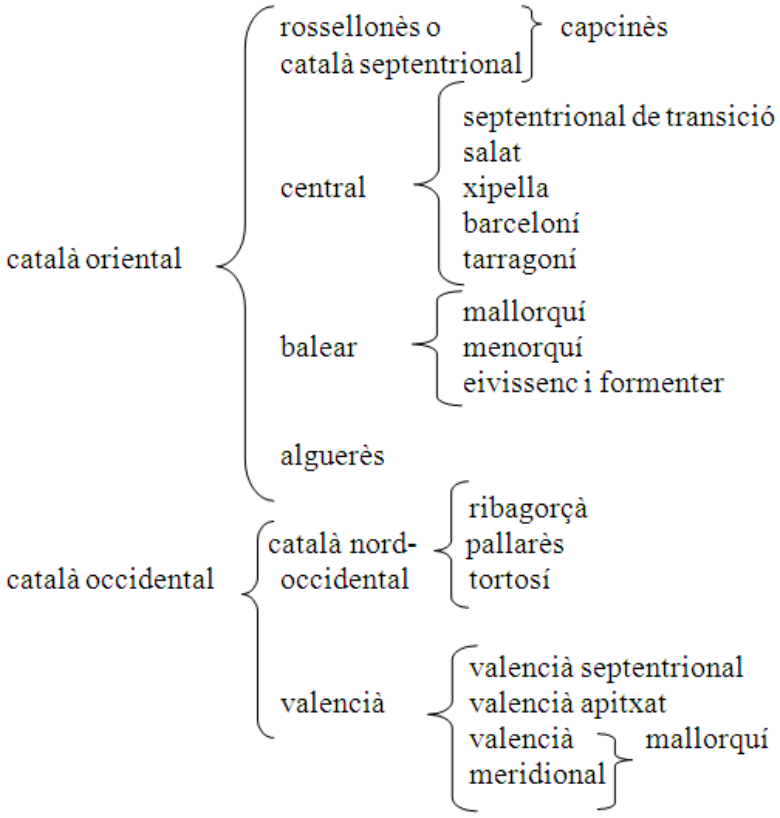


Figure 6: Tree diagram of the Catalan dialects (adapted from Veny, 1982/2002:23). Names have been left as in the original Catalan version.

A final consideration should be added to avoid taxonomical confusion. *Eastern varieties* (sometimes called the *Eastern block*) are roughly intended as the varieties spoken in the eastern territories presented in Fig. 4, while *Eastern Catalan* specifically refers to the variety spoken in the eastern areas of the Catalonia region (see, in Fig. 5, the area marked with vertical lines), and hence it excludes the Catalan varieties spoken in the Balearic islands, Alghero and French Catalonia. Analogously, *Western Catalan* is intended as the variety spoken in the western areas of the Catalonia region (see, in Fig. 5, the area marked with horizontal lines), and should not be confused with the term *Western varieties* (or *Western block*), which also includes Valencian.

In § 1.1, 1.2 and the current section, some general information has been provided on Sardinian and Catalan varieties. In the sections to come, more details will be added on the possible sociolinguistic mechanisms at work during the period of the shaping of Algherese (14th and 15th centuries), and those operating during the later modification of the same

variety. This further level of analysis is aimed at providing the researcher with suitable keys of interpretation of the experimental data in the Results section. In this respect, Fig. 7 contains a sketch of the possible theoretical problems in defining if and to what extent Algherese vowels acoustically resemble more those of Sardinian or those of another Catalan variety.

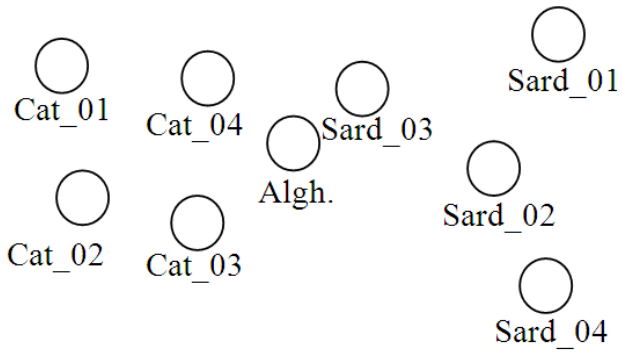


Figure 7: Possible simulation of mean vowel formant frequency distances between Algherese and other Catalan and Sardinian varieties. This simulation has been devised to show that the results of the comparison can potentially be interpreted in different ways. If the comparison is exclusively carried out by finding the closest variety to Algherese, Sard_03 would be the case, whereas if the mean values for each dialect as a function of 'language' are computed, Algherese vowels would turn out to be more similar to those of Catalan instead.

The graph shows possible overall formant distances between Algherese and each variety of Catalan (i.e. Cat_01, Cat_02, etc.) and Sardinian (i.e. Sard_01, Sard_02, etc.). In this regard, if the comparison is carried out in terms of the closest mean formant frequency values of Algherese with respect to those of a specific Catalan or Sardinian dialect, Sard_03 would be considered the closest variety. By contrast, if the mean distances of each variety are averaged as a function of 'language' (i.e. Catalan vs. Sardinian), the acoustic values of Algherese vowels would be said instead to be more similar to those of Catalan.

This is not the only possible problem concerning the correct interpretation of the acoustic values among the varieties under investigation. In fact, according to different studies (see Calamai, 2003, for two Tuscan varieties and Recasens & Espinosa, 2006, for four Catalan varieties), formant frequency differences can be found among correspondent vowels in dialects of the same language. In this respect, if we consider two given heptavocalic varieties of a given world language, it is almost certain that one of those vowel systems would be formantically closer to the Algherese vowel system than the other (unless the vowels of the two varieties are formantically identical). In this case, the lesser formant distances of one of

the two systems should be considered merely accidental, and would have nothing to do with the hypothesis to be tested in the present study of Algherese vowels as the result of sociolinguistic and repopulation-related facts regarding the history of the city. In the examples reported in Fig. 7, both Sardinian and Catalan varieties are expected to potentially have played a role in determining the current quality of Algherese vowels, and hence the greater affinity to the latter system by a given Sardinian or Catalan variety should not be considered in principle as entirely accidental. At the same time, it is believed here that the formant frequency data gathered for the vowel comparison should be also tested against the documents and the literature available on the historic immigration and adstratum contacts concerning the city of Alghero. In the specific case of the variety Sard_03 in Fig. 7, the high formant proximity to Algherese would be considered 'less accidental' if documents were found to provide evidence of constant immigration to Alghero from territories where that Sardinian variety is spoken, and also of constant commercial and/or other adstratum contacts between Alghero and territories where Sard_03 is spoken (the same considerations are of course valid for Catalan varieties).

As anticipated above, some information on the repopulation of the stronghold of Alghero and on its commercial and adstratum contacts with the rest of Sardinia and also with different Mediterranean port cities will be dealt with in the following sections.

1.4 The repopulation of Alghero from a linguistic perspective

The territory of Alghero is rich in testimonies of anthropic presence since the Neolithic Era. The foundation of the stronghold of L'Alighera or S'Alighera (the first names of the city) probably dates back to the second half of the thirteenth century, by means of the powerful Genoese family of Doria.[42] As anticipated above at the beginning of § 1.1, the militia of the Crown of Aragon had to besiege the city twice, in 1353 and 1354, before definitely taking possession of the stronghold, and, to avoid future rebellions, the original Genoese and Sardinian inhabitants were replaced by colonists and soldiers coming from the territories of the Crown. This ethnic-oriented repopulation policy formally lasted until 1495, the year of the Tarazona Edict, under which the Algherese councillors were given the authority to allow also Sardinians to reside in the city.

[42] See Bertino, 1989, Chapter V.

A very important issue related to the introduction of Catalan language into the city is that, as scholars generally acknowledge, the great majority of colonists came from Catalan-speaking areas of the Crown of Aragon. Is it possible to determine the exact places of origin of those Catalan-speaking settlers? Answering this question could help us defining which Catalan variety might have given the main contribution in shaping early Algherese.

In this respect, the historian Sigismondo Arquer writes in his *Sardiniae brevis historia et descriptio* (1550): '*Alghер, civitas nova […] cuius incolae fere omnes Tarraconenses sunt*'.[43] This statement can be probably put into question by some historic events. In fact, the immigration from Catalan-speaking areas proved not to be sufficient to cope with the serious demographic and economic depression already in the years following 1492, i.e. after the expulsion of the Jews from all the territories of the newly formed Kingdom of Castile and Aragon, Alghero included.[44] This fact obliged the public authorities to remove a ban against the immigration of Sardinians which had lasted (with some exceptions) for almost 150 years. As a consequence, already in 1546, i.e. just four years before Arquer writes his *brevis historia*, more than 50% of the children baptised in Alghero possessed a Sardinian surname,[45] a fact which makes at least questionable the description made by Arquer of Algherese people as coming 'almost entirely from Tarragona'. It is then possible that he simply refers to the possible *origin* of the Catalan settlers, even though this remains a mere supposition, since he does not mention the source of his information. In one recent research work by Conde,[46] Tarragona appears among the places of origin of the first settlers, but many other Catalan-speaking cities and towns appear to be equally or even more represented in quantitative terms. The documents quoted by Conde indicate that colonists roughly came from all the Catalan-speaking areas (i.e. Catalonia, the Valencia region, the Balearic islands and French Catalonia), and also from other non-Catalan-speaking areas of the Iberian peninsula (such as Aragon), in addition to Sicily, Corsica and Sardinia.[47]

All this said, it is not impossible to hypothesise that, since the very first decades following the Aragonese conquest of the stronghold, the language spoken by the Algherese inhabitants

[43] 'Alghero, a new city […] whose inhabitants came almost entirely from Tarragona'. See Arquer, 1550/2007:24.
[44] See Budruni, 2010b:23.
[45] *Ibid.*, p. 24.
[46] See Conde, 1994.
[47] *Ibid.*, p. 92. As regards non-Catalan settlers, and specifically those of Sicilian, Corsican and Sardinian origin, the author mentions examples of some original inhabitants of Alghero who were not expelled after the occupation of the stronghold by the new conquerors since they had 'collaborated' with the latter during the siege (p. 76).

could include specific elements of different Catalan varieties, and Algherese could resemble a sort of Catalan *koine*. This view would be in accordance with the studies by Caria (1990) and Corbera (1995), concerning the concurrence in Algherese of linguistic elements of both Western and Eastern varieties, and also with the Algherese outcomes in the inter-Catalan comparison made in Table 1 of the present study.

As anticipated in the first part of this section, the Tarazona Edict of 1495 ends the ban prohibiting Sardinians from residing in the city which had started (with some few exceptions) immediately after the second conquest of the city, in 1354. If we look back at the figures quoted by Budruni (2010b:24) with regard to the surnames of children baptised in Alghero in 1546, i.e. just 51 years after the Tarazona Edict, it is worth mentioning that more than half of them already presented a Sardinian surname, while 'only' a third (34%) still had a Catalan surname. At first glance, this sudden shift in the ethnic composition of the population, due to which the Catalan origin inhabitants seemed to have become a 'minority' ethnic group within the city in just fifty years, raises the very question of how has it been possible for Algherese Catalan to survive.

A first answer could come from a more careful analysis of the data provided by Budruni. For example, it could be useful to remember that the earlier ban on Sardinians residing in the city had included some exceptions, such as in the Edict of 1362, in which Algherese widows were 'invited' to get married to Catalans, Aragonese and even Sardinians.[48] This implies that some Sardinian surnames were already present in the city long before the Tarazona Edict, and that some of the children baptised in 1546 presenting a Sardinian surname actually belonged to Catalan-speaking families. Also, the data of 1546 should be considered a mere 'snapshot' taken at the end of a period that had lasted for 51 years, in which the arrival of Sardinian (but also Ligurian) immigrants was presumably more or less gradual, giving time to the newcomers (and especially to their offspring) to become naturalised inhabitants of the city.

The historic linguistic naturalisation of the newcomers is an issue which does not need to be demonstrated, given the fact that Algherese was still the mother tongue for the majority of Algherese people until a few decades ago, and still is for many of them; instead, historians and linguists have often devoted their research to trying to understand the social dynamics

[48] See Conde, 1994:88.

which allowed the survival of Algherese in spite of the ethnic shift in the population away from its Catalan origins. Immediately after 1495, the newly formed Kingdom of Castile and Aragon had to guarantee that the empty space left in Alghero by the forced departure of the Jews was filled by new inhabitants, and, since this could not be achieved any longer through people coming from the Iberian territories, the gates of the city were opened to 'foreign' (i.e. Sardinian) immigrants. At the same time, the public authorities accorded new citizenships through '*una oculata politica di assimilazione sempre più affidata ad elementi di natura più squisitamente culturale*', by means of the preservation of the '*lingua catalana negli atti e nella vita quotidiana*'.[49] From the point of view of the immigrants, access to the city also meant access to an urban area with many economic and political privileges,[50] which was certainly worth the price of cultural assimilation.

Other important dates in the process of repopulation of the city are normally said to be 1582–1583 and 1652, i.e. the years in which two great plagues affected Alghero and the rest of Sardinia,[51] even though immigration remained a capital factor in the demographic growth of the city also in the years preceding and following the two plagues.

As mentioned above, the newcomers mainly hailed from the rest of Sardinia, but also from Liguria, Campania and other areas of the Italian peninsula and the Western Mediterranean, and they gradually substituted the Catalan origin population. In spite of this total ethnic shift, the Catalan language managed to survive long after any political contact ceased to exist between the Iberian authorities and the city of Alghero, i.e. after 1720, the year in which the Crown of Castile was forced to give up Sardinia to the House of Savoy.[52] In other words, the transmission of Algherese was carried out, over the centuries, by its very inhabitants, independently of their Catalan or Sardinian or Italian (geographically speaking) origin, since Algherese Catalan was *their own* language. Of course, it would be at least naïve to think that this process of linguistic and cultural naturalisation did not in itself have the effect of modifying Algherese. With respect to the immigration from the Sassari area and the rest of

[49] 'a careful assimilation policy based more and more on cultural aspects', by means of the preservation of the 'Catalan language in official documents and everyday life' (see Anatra, 1994:332).
[50] See Mattone, 1994 and Tavera & Piras, 2007.
[51] See Serri, 1994 and Budruni, 2010b.
[52] Following the War of Spanish Succession (1700–1708), the House of Habsburg took control of Sardinia (1708–1717) and, after a short-lived reconquest of the island by the Spanish Crown in 1717–18, the Treaty of London of 1718 definitively assigned Sardinia to the House of Savoy (see Sole, 1984).

Sardinia into the city, and the consequent process of linguistic assimilation those immigrants were subject to, Bosch (2002:16) writes:

> […] els parlars sards són abandonats en favor del català per part de la immigració sardòfona i sassaresòfona, però que el català ja no serà el mateix català després de l'assimilació lingüística d'aquest grup […][53]

Many authors have also highlighted the condition of Algherese as an isolated Catalan linguistic island in a totally Sardinian- and Sassarese-speaking environment, and this geographical condition, too, has certainly contributed, over the centuries, to a partial 'sardisation' of this Catalan variety. The two dimensions of possible linguistic changes – from the inside, brought about by immigrants, and from the outside, through the important adstratum relationships between Algherese people and their Sardinian-speaking neighbours (and also in terms of commercial exchange with the other port cities of the Mediterranean[54]) – will be analysed in detail in the next section.

1.5 Adstratum and substratum interferences on Algherese from Sardinian and other languages

In the previous section some considerations were made with respect to the possible places of origin of the first Catalan settlers, with the aim of gathering some information on what Catalan variety could have had the most importance in shaping early Algherese Catalan. The possible influences of one or more Catalan varieties on Algherese can, however, also be discussed on a different level, that of the *adstratum*. This term will be used here as *linguistic contact* in its most general meaning, i.e., in the case of Alghero and many other port cities of the world, as the relationship between the urban area and its hinterland, but also, in a complementary way, in reference to commercial contacts with other port cities.

With regard to the latter, historians have found many examples of intense trade between Alghero and Barcelona, which can also give us important information on the linguistic contact between the two cities and the possible influence of Eastern Catalan (i.e. the variety spoken in Barcelona and the rest of eastern Catalonia) on Algherese. Just to mention some quantitative data on this relationship, Anatra (1994:328) calculates that, between 1436 and 1493 '[…] non

[53] '[…] the Sardinian varieties have been abandoned in favour of Catalan by Sardinian- and Sassarese-speaking immigrants, but Catalan will not be the same Catalan after the linguistic assimilation of this group […]'.
[54] The relationship between Algherese sailors and other Sardinian people and fishermen all along the west and north-west coast of the island, during the fishing season, should also be borne in mind.

più del 35% delle assicurazioni stipulate in Barcellona per naviglio diretto in Sardegna indicano Cagliari come scalo terminale. In tutte le altre compare Alghero, il più delle volte da sola, alcune altre assieme a Bosa e/o, ma in posizione del tutto marginale, Oristano e Porto Torres […]'.[55]

Commerce between Alghero and Barcelona, and also Valencia, is said by Caria to have continued even after 1720, when Sardinia ceased to be part of the Spanish Crown and passed to the House of Savoy.[56] The arrival (though sporadic) of ships from Catalan-speaking areas is still present in the memory of some elderly inhabitants of Alghero.[57]

Over the centuries the space left by the decline of the commercial relationship between Alghero and other Catalan-speaking cities was filled by vessels from other parts of the Mediterranean, particularly from the Italian peninsula. In a research study concerning the traditional maritime lexicon of Alghero, Caria (1995) calculates that almost 300 words (i.e. one-third of the total words analysed) are a local adaptation of loans from (in order of importance) Neapolitan, Genoese, Sardinian, Sicilian and, in a residual manner, Corsican and Tuscan.

If it is true that this Mediterranean projection played a part over the centuries in modifying Algherese, particularly in its lexical heritage, it is nonetheless true that the adstratum contact between the city and its hinterland seems to have modified this variety of Catalan even more, and the important presence of loans from Sardinian is a factor which has been pointed out by many scholars.[58] This is quite comprehensible, given that the territory of Alghero is surrounded by areas where Sardinian is spoken (in its Northern Logudorese variety), and also Sassarese. It is not by chance that different authors, such as Kuen (1932:127) and Clavellet (1906/1991:107) provide evidence that the Sardinian and Sassarese languages were normally known by the people of Alghero, and also that knowledge of these languages was

[55] '[…] not more than 35% of insurance policies stipulated in Barcelona for shipping bound for Sardinia indicate Cagliari as the final destination. In the others the destination is Alghero, most of the time alone but sometimes along with Bosa and/or (in a marginal number of cases), Oristano and Porto Torres […].'

[56] The author writes that there are hundreds of notarial acts witnessing '[...] la constant relació mercantil de l'Alguer encara al segle XVIII, particularment amb Barcelona i amb València [...]' ('[…] the constant trade relationship, even in the eighteenth century, between Alghero and, in particular, Barcelona and Valencia') (see Caria, 1995:120).

[57] For example, Giovannino Frulio, a caulker from Alghero (born in 1934), told the author of the present study how he remembered walking by the harbour as boy, and, all of a sudden, hearing foreigners on a docked boat talking roughly his same language. Intrigued by this, he found out that those sailors came from the island of Majorca, where Majorcan Catalan is spoken.

[58] See, among others, Guarnerio, 1886, Palomba, 1906/2001, Kuen, 1932, 1934.

indispensable for merchants living in the city who wished to sell their products outside the urban area.[59] During the first years of the twentieth century, at the time Clavellet is writing, Alghero is also developing into a seaside resort, receiving every summer 'gran part de la gent de Sàsser'.[60]

When comparing the influence on Algherese of Sassarese vs. Logudorese, however, Clavellet does not hesitate to attribute the primary role to the latter, particularly through the sociolect spoken by shepherds and farmers working in the area known as the *Nurra Algherese*:

> Aquesta rama és la que més ha influït sobre l'alguerés tenintlo como assitiat a dins de una gran cadena de pahisos que'l voltejen; L'Olmedo, Uri, Putifigari, Itiri, Vilanova, Bosa.[61]

On the basis of the dialectal taxonomy proposed above in § 1.2, five of the towns mentioned by Clavellet ('L'Olmedo', 'Uri', 'Putifigari', 'Itiri' and 'Vilanova') fall into the Northern Logudorese variety, while one ('Bosa') is part of the Common Logudorese area.

To broaden the range of possible adstratum contacts between Alghero and other areas of Sardinia, it should not be forgotten that for centuries Alghero, owing to its political role during the period of Catalan and Spanish domination, maintained relationships with many other Sardinian towns, especially in the northern half of the island. In 1412, for example, Ferdinand I of Aragon ordered that the export of wheat from Sardinia was to take place exclusively from the ports of Cagliari (southern Sardinia) and Alghero,[62] and it is not hard to imagine the constant arrival of people from many central and northern areas of the island, people bringing with them wagonloads of grain to be shipped from the port of the city. Between 1596 and 1737 the towns enfeoffed to the city still covered vast portions of northern Sardinia, including not only Northern Logudorese-speaking areas, but also those where Common Logudorese, Nuorese, Gallurese and Sassarese were spoken.[63]

[59] See Clavellet, 1906/1991:107. A very curious example reported there is that of the 'mercant de peix' ('fishmonger') who went to the territories outside the city to sell his fish.
[60] '[…] a large part of the people from Sassari'. *Ibid.*, p. 106.
[61] 'This branch [of Sardinian] is the one which has influenced Algherese the most, the latter being almost besieged and surrounded by a vast chain of towns: L'Olmedo, Uri, Putifigari, Itiri, Vilanova, Bosa'. *Ibid.*, p. 111. The author uses the adjective Logudorese in the traditional extensive sense of 'centre-northern Sardinian' ('…domina més que mitja Sardenya'; '…it spreads over half of Sardinia').
[62] See Budruni, 2010:66.
[63] See Archivio Storico Comune di Alghero (A.S.C.A.): 3.9.2 'Scrutinio del grano ville infeudate', years 1596-1737. The list of the towns and districts enfeoffed to Alghero is given in Appendix III.

Is it possible, then, to claim that the influences of Sardinian on Algherese Catalan are due to the centuries-old contacts between Alghero and the rest of the island? There is no doubt that the adstratum contact played an important role in modifying Algherese, but it is nonetheless true that another factor played an equally (or even more) important role in that process, namely the gradual substitution of the Catalan origin population with immigrants from the rest of Sardinia. In this respect, Bosch (2002:18) writes:

> [Algherese] presenta un alt grau de sardismes, no atribuïbles exclusivament –com s'ha dit fins ara– a les relacions de veïnatge o adstrat amb altres comunitats lingüístiques illenques –la sarda i la sassaresa– sinó a les interferències de substrat –sard i sassarès– per la penetració massiva a l'Alguer de població de Sardenya [...][64]

Following Bastardas (1996:25), Bosch uses the term *substratum* to indicate the influence of the L1 or mother tongue of Sardinian immigrants during their acquisition of Algherese, and this is also the acceptation used in the present work.

In this respect, some information on the Sardinian variety that may have had a greater influence on Algherese as a substratum language could come from corresponding information concerning the places of origin of the newcomers. It is normally noted by scholars that a significant demographic contribution to the total number of residents in the city came in the years following the two plagues of 1582–83 and 1652,[65] when many Sardinian families emigrated to Alghero. Budruni (2010b:70) makes a list of the places of origin of immigrants getting married in Alghero in 1586 (i.e. in the years following the great plague of 1582–83). As may be expected, the great majority are Sardinian:

[64] '[Algherese Catalan] shows a significant presence of words of Sardinian origin not exclusively attributable – as has been claimed so far– to proximity or adstratum relations with the other linguistic communities of the island – Sardinian and Sassarese – but rather to substratum interferences – of Sardinian and Sassarese – as a result of the mass penetration of the Sardinian population in Alghero […]'.
[65] See, Among others, Anatra, 1994:332-333 and Serri, 1994.

Villanova Monteleone [NLog.][66]
Bosa [CLog.]
Padria [CLog.]
Cuglieri [CLog.]
Scano Montiferru [CLog.]
Monteleone [NLog.]
Sassari [Sass.]
Cheremule [NLog.]
Torralba [NLog.]
Ozieri [NLog.]
Bonnannaro [NLog.]
Ittiri [NLog.]
Ploaghe [NLog.]
Bultei [CLog.]
Illorai [CLog.]
Bessude [NLog.]
Ossi [NLog.]
Nughedu [NLog.]
Orotelli [Nuor.]
Silanus [CLog.]
Orani [Nuor.]
Ilbono [Camp.]
Cagliari [Camp.]

As the author points out, the majority of the newcomers hailed from towns and villages included in the vast diocese of Alghero (see Fig. 8). From a dialectal point of view, the immigrants came from Northern Logudorese (11) and Common Logudorese (7) speaking towns, but also from areas where Nuorese (2), Campidanese (2) and Sassarese (1) were spoken.

[66] The Sardinian variety each town belongs to is given in brackets. For the sake of simplicity, only immigration from the rest of Sardinia is considered here, and not immigration from other regions such as Liguria. Sardinian immigration provided by far the most important contribution to the repopulation of the city. Budruni (2010b) calculates that in 1586, 73% of couples getting married in Alghero had Sardinian surnames.

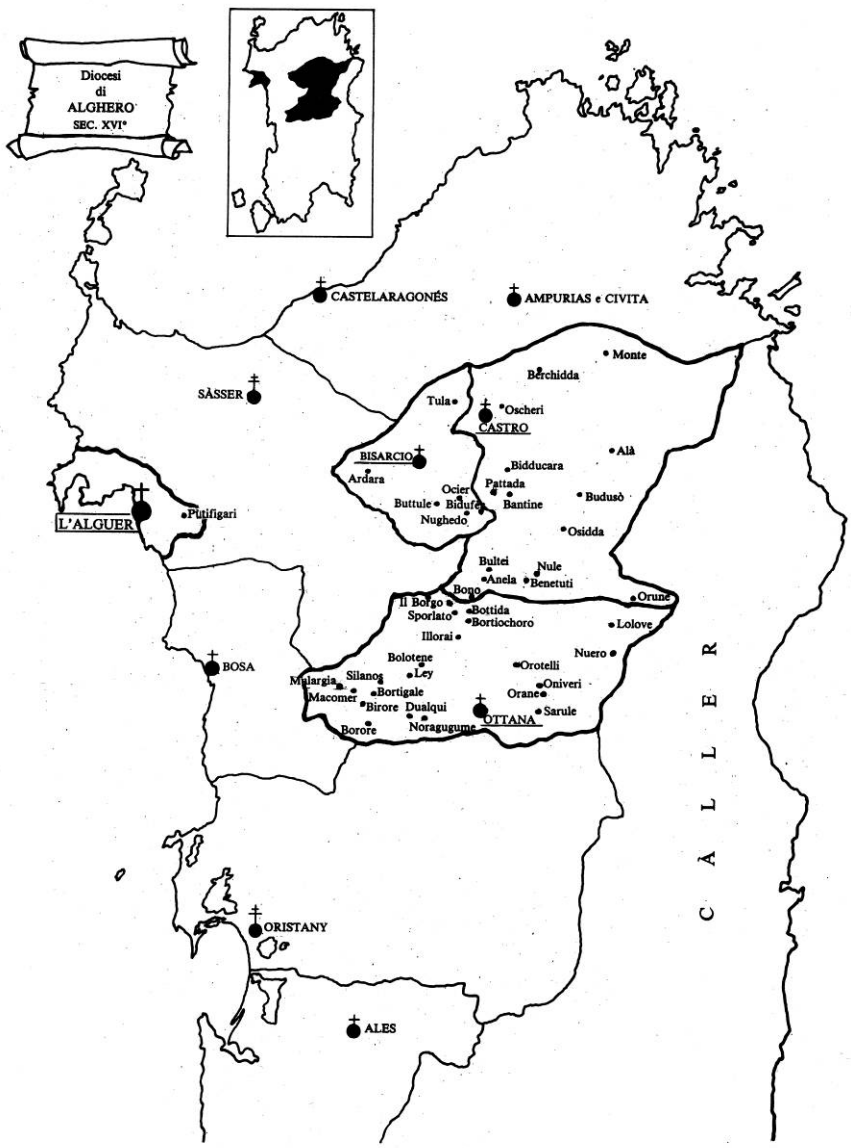


Figure 8: Territories belonging to the Diocese of Alghero from 1503 until the late eighteenth or early nineteenth century (extracted from Nughes, 1990:41).

Similarly, in a study by the same author[67] of the registers of weddings held in Alghero after the great plague of 1652, the majority of spouses (especially grooms) were Sardinian immigrants, coming mainly from Northern and Common Logudorese speaking areas, but also from Sassarese, Nuorese and Campidanese dialect zones.

[67] See Budruni, 2010b, Chapter IX.

As regards immigration from the Italian peninsula, the same documents indicate that the repopulation process was also characterised 'da un discreto flusso migratorio Ligure'.[68] The other important Italian migration to Alghero was from the Campania region, particularly after the end of the eighteenth century.[69]

The two periods analysed by Budruni show an immigration pattern which seems not to have changed much over the centuries in terms of the demographic predominance of Sardinians among the total number of newcomers. In this respect, a detailed survey of the place of origin of the inhabitants of Alghero has been carried out by the author of the present study on the basis of the general census of 1921, and in particular the socio-demographic data on inhabitants conserved in the Historical Archives of the City of Alghero (A.S.C.A.).[70]

The total resident population in 1921 was 12,280, but only the records of 11,900 inhabitants are still kept in the archive registers. The sociolinguistic analysis was therefore only carried out on this latter group.

A first general division can be made between people who were native to the city (who supposedly had Algherese as L1) and new residents, i.e. people reported as not born in the city. People of the first group accounted for 83.6% of the total residents, and those of the second group for 16.4%. Table 2 shows in detail the places of origin of the latter category, i.e. residents who were not born in the city.

Consistent with the data from Budruni regarding previous centuries, the bulk of the new inhabitants of Alghero are still shown to come from the rest of Sardinia (i.e. 81.9%), and especially from Northern Logudorese-speaking areas (59.6% of all Sardinian immigrants and 48.8% of the total immigration). As regards Italian immigration, there is a prevalence of people from northern regions over those from central and southern regions. In terms of individual Italian regions, Campania and Liguria (31 residents from each region) are the most represented.

[68] '[…] by non-negligible migration from Liguria'. *Ibid.*, p. 71 and Chapter IX.
[69] *Ibid.*, p. 111.
[70] See A.S.C.A., VI Censimento della Popolazione (1 Dicembre 1921): Fogli di Famiglia o Convivenza. The data were analysed in the digitalised version.

	tot.	1950	100.0%
place of origin	Sardinia	1597	81.9%
	Italy	266	13.6%
	abroad	51	2.6%
	unknown	36	1.8%

residents not born in Alghero but in other parts of Sardinia

	tot.	1597	100.0%
place of origin (in terms of the supposed L1)	NLog.	952	59.6%
	CLog.	206	12.9%
	Camp.	133	8.3%
	Nuor.	23	1.4%
	Nurra	17	1.1%
	Sass.	237	14.8%
	Gall.	28	1.8%
	Tabar.	1	0.1%

residents born in Italy

	tot.	266	100.0%
	north	115	43.2%
	centre	73	27.4%
	south	78	29.3%

Table 2: Places of origin of residents of Alghero not born in the city, according to the general census of 1921. The toponym 'Nurra' (i.e. the plain extending between Alghero and Porto Torres) implies that people born in that area might have also had Algherese and/or Sassarese and/or Northern Logudorese as their L1. The abbreviations 'Tabar.' and 'Gall.' stand for, respectively, Tabarkino (i.e. the Ligurian variety spoken in the towns of Carloforte and Calasetta) and Gallurese (i.e. the Corsican-based variety spoken in the northernmost regions of Sardinia).

An even broader picture, on the diachronic axis, of the places of origin of the new inhabitants of Alghero is provided by another document present in A.S.C.A., namely the *Registri annuali Atti di Morte dal 1866 al 1935*. These registers contain a list of the 21,993 death certificates of people who died in Alghero between 1866 and 1935, and also include residents of Alghero who died outside the city during the same period.[71] It is reasonable to assume that some of

[71] One very interesting example of an Algherese resident who died outside his homeland is that of Giovanni Antonio Repetto. At first glance, the author of the present study did not know exactly how to interpret the declared place of birth, which was written as 'Balzarona', i.e. a phonetic form of the Algherese pronunciation of the Catalan city of Barcelona. In fact, in the same document 'Balzarona' was declared to belong to the Sassari province, which was (and still is) the county seat to which the territory of Alghero belongs, hence 'Balzarona' is to be considered a clear reference to the historic nickname of Alghero, i.e. 'Barceloneta'. The intriguing issue was how it could be possible for an official document not to report the real name of a given place of origin, but a nickname instead. A possible answer could come from a further investigation into the issue by G. Piras, archivist of A.S.C.A., who found out that the place of the death of Repetto, which was an unspecified 'ospedale della

these deaths were of people who were only in Alghero 'by chance', for example prisoners during the Great War or people pursuing their trades in the city, and can hardly have contributed to shaping Algherese in the way Bosch (see above in the current section) describes as *substratic*, i.e. living in the city for most of their life and using, at the same time, a version of Algherese adapted to their mother tongue. For these reasons, the names of the 2,328 people who were not residents of the city have been excluded from the analysis of the places of origin of people listed in the register. The results of this investigation are shown in Table 3. In particular, the table shows the place of origin of the 2,116 residents who were not born in Alghero (i.e. 10.8% of the total 19,665 residents).[72]

	tot.	2116	100.0%
place of origin	Sardinia	1618	76.5%
	Italy	440	20.8%
	abroad	41	1.9%
	unknown	17	0.8%
	residents born in other parts of Sardinia		
	tot.	1614	100.0%
place of origin (in terms of the supposed L1)	NLog	916	56.8%
	CLog.	185	11.5%
	Camp.	165	10.2%
	Nuor.	34	2.1%
	Nurra	22	1.4%
	Sass	255	15.8%
	Gall.	33	2.0%
	Tabar.	4	0.2%
	residents born in Italy		
	tot.	440	100.0%
	north	197	44.8%
	centre	88	20.0%
	south	155	35.2%

Table 3: Places of origin of residents of Alghero who were not born in the city, according to death certificates from the period 1866–1935.

croce rossa', was actually the hospital of the Red Cross of Prato (Tuscany). Hence, it is not impossible to imagine that, being hundreds of miles away from home, the soldier Repetto gave some official, before dying, the name he liked the most, i.e. 'Balzarona', safe in the knowledge that the geography of Sardinia was quite unknown to many 'continentals'.

[72] People born in the Valverde area, on the outskirts of Alghero, were included among residents born in the city.

Once again, the immigrants to Alghero mainly come from the rest of Sardinia (76.5%). Among them, the variety which is most represented as the L1 of the newcomers is Northern Logudorese (56.8% of all Sardinian immigrants and 43.3% of the total immigration), followed (in descending order) by Sassarese, Common Logudorese, Campidanese, and Nuorese.

With respect to Italian immigrants, a relative majority of the newcomers came from northern regions, followed (in descending order) by southern and central areas. In terms of individual regions, the most represented are still Campania (117 residents) and Liguria (74).

In sum, the historical data gathered so far would be consistent with the claims by some authors who consider Sardinian, in particular its Northern Logudorese variety, to be the language that has contributed the most to modifying Algherese Catalan.

A last consideration should be made of the possible effects of standard Italian on the quality of Algherese vowels. The influence of the latter language on Algherese has been pointed out by many authors (see, among others, Blasco Ferrer, 1994, Caria, 2006), particularly as regards the gradual introduction of loans from standard Italian since the twentieth century. At the phonetic/phonological level, however, an instrumental study carried out by the author of the present work[73] clearly shows that the only visible influence on current Algherese vowels comes from the pressure of Sardinian metaphony, and that Italian too, when it is spoken by Algherese people, is systematically adapted to Sardinian metaphony rules. This does not mean that a possible influence of standard Italian on the acoustic characteristics of Algherese vowels should be totally excluded, but, at the same time, the instrumental data available so far suggest that it is unlikely that this superstrate language has contributed more to the acoustic (re)definition of Algherese vowels than languages such as Sardinian.

[73] See Ballone, 2010.

1.6 Framing the experimental hypotheses: are Algherese vowels acoustically Sardinian or Catalan?

1.6.1 Phonetic and phonological changes

As seen in the previous sections, Sardinian interferences on Algherese have frequently been analysed in the literature covering the lexical dimension, but also in terms of phonetic, morphological and syntactic modifications.[74] This approach assumes that the present phonetic and phonological state of Algherese is not only the outcome of physiological and intrinsic linguistic changes, but also the result of the interaction between possibly innovative factors, such as changes brought about by massive immigration over a long historical period, and possibly conservative factors, such as the native-like competence in Algherese acquired by the sons and daughters of immigrants born in the city.

From a phonological point of view, no general shifts seem to have been brought about by Sardinian immigration on the Algherese vowel system, given the fact that Algherese still preserves its original heptaphonemic inventory, whereas northern Sardinian varieties present a pentaphonemic one. In this respect, an effort probably had to be made by people from northern Sardinia to use the open-mid vowels /ɛ/ and /ɔ/ as distinct phonemes with respect to /e/ and /o/, respectively, since in that linguistic system the close-mid vowels are simply allophones of their open-mid correspondents and are only used in specific phonetic contexts.[75] As a consequence, Logudorese (and also, to a certain extent, Campidanese) speakers had to learn how to re-categorise their mid vowels by using them no longer in a complementary position (as is the case in their L1), but instead as distinct phonemes. For example, in trying to correctly realise the Algherese word 'd[ɛ]u' ('ten'), they had to learn how to produce the front open-mid vowel *also* before a close vowel, but, in doing so, they could still look for an acoustic referent they were familiar with, i.e. the Sardinian phoneme /ɛ/. Similarly, in pronouncing the Algherese word 's[e]t' ('thirst'), Sardinian speakers probably found it strange to have to produce a close-mid vowel which was *not* followed by a close or close-mid one; yet again, in trying to learn the correct pronunciation of that word they could nonetheless refer to the Sardinian correspondent [e].

[74] See, among others, Kuen, 1932-34, Contini, 1995, Bosch, 2002.
[75] This is due to the process widely known as Sardinian metaphony, which will be discussed in more detail in § 2.3 below. To facilitate the comprehension of the issues discussed in the current section, it will be sufficient to anticipate now that Sardinian mid vowels are normally (but not always) uttered as close-mid when they are directly followed by a close-mid or a close vowel, and as open-mid in other cases.

Some remarks were made above on the fact that no general phonological shifts seem to have affected the Algherese vowel system. The adjective 'general' was deliberately chosen in order to leave open the possibility of specific phonological changes having happened instead. In this regard, Kuen (1934:130) hypothesises that:

> En alguerés antiguo, como en antiguo catalán oriental y en baleárico, la **ẹ** estaba representada por **ə**, que más tarde ha pasado de nuevo a **ẹ** por influencia del sardo, el cual no posee vocales mediolinguales.[76]

In principle, it is not impossible that the lack of schwa in the majority of Sardinian varieties (although with some exceptions[77]) might have contributed to the recovering[78] of stressed [e] from [ə]. A not irrelevant objection to Kuen's hypothesis, however, comes from the fact that Sardinian, as will be better explained in § 2.3, possesses both the open-mid and close-mid front vowels [e] and [ɛ], so it remains unclear why only the influence of the former should have altered the quality of the supposed original schwa. Additionally, the presumed influence of Sardinian on Algherese in the recovering of the front vowel in, to mention just one example, the Catalan word 'cera' ('wax'), from Latin CĒRA, would have given the realisation [ˈsɛɾa] with the open-mid front vowel [ɛ] as a consequence of the Sardinian metaphony process, whereas the actual pronunciation of that word in Algherese is [ˈseɾa] with a close-mid stressed vowel instead. Another weak point in Kuen's assumption is that he simply takes it for granted that, with regard to the evolution of Latin Ẹ (i.e. Ē), Algherese followed the evolution of Eastern Catalan varieties (i.e. [e] > [ə]), excluding any possibility of western colonists contributing to the maintaining of stressed [e] in Algherese. The reason for this probably lies in the fact that at the time of Kuen's study on Algherese, information concerning the place of origin of the first settlers was very scarce, and the only three cases for which this information was available indicated an Eastern origin of the newcomers.[79]

Having said this, in certain words the influence of Sardinian on Algherese does seem quite probable. For example, it is well known that the realisations [ɛ] and [ɔ] in unstressed position

[76] 'In ancient Algherese, as well as in ancient Western and Balearic Catalan, Ẹ [i.e. Latin [e]] was represented by [ə], which later became again [e] due to Sardinian influence, since the latter does not possess mid-central vowels'.
[77] See Cossu, 1997/2009.
[78] It would be probably more correct to say the *keeping* of the same vowels, since the first passage 'stressed [e] from Latin Ē → [ə]' in Algherese Catalan remains unproven.
[79] See Kuen, 1932:124. The author refers to Era, 1928, according to whom the three Catalan colonists whose origin was detected came from Barcelona (two subjects) and Majorca (one subject), i.e. two areas belonging to the Eastern Catalan varieties.

are normally avoided in Catalan dialects, due to the application of the vowel reduction process;[80] by contrast, some Sardinian loans show, in their Algherese adaptation, the original (i.e. Sardinian) open-mid vowels in unstressed position: 'arest[ɛ]' and 'iel·l[ɔ]'.[81] In other words, current Algherese – unlike other Catalan varieties – presents unstressed open-mid vowels due to the influence of the normal Sardinian pronunciation of mid vowels (i.e. they possess an open-mid quality when not affected by metaphony). In a limited number of cases it is also possible that the pressure of Sardinian metaphony is starting to affect Algherese vowels in the stressed domain, such as in 'parr**ò**quia' ('parish') and 'vict**ò**ria' ('victory'), in which stressed 'o' vacillates, according to the speaker, between the expected Algherese pronunciation [ɔ] and the metaphonised one [o].[82]

On the one hand these instances can be considered to be presumably caused by the direct or indirect pressure of Sardinian on Algherese, but, on the other, they have to be treated as exceptions to a vowel system which is still today undoubtedly Catalan, at least from a phonological point of view. This being said, is it also possible to affirm that Algherese vowels still maintain their Catalan origin quality in the acoustic dimension? In this regard Fig. 9 shows that answering this question presents a number of problems. In fact, even though the vowel inventories of Algherese and Logudorese differ in terms of contrastive vowels, the two systems are normally plotted as presenting their allophones in rather similar positions in the vowel space.

[80] See Mascaró, 2002. The author indicates some specific exceptions to the rule, such as the Valencian *vowel harmony*, in which unstressed [ɛ] and [ɔ] can be found in some words as allophones of /a/.
[81] See 'areste' and 'iel·lo' in Sanna, 1988, and also in Ballone, 2008 for a further discussion of these realizations.
[82] See Ballone, 2010. The same phenomenon can be sometimes detected in loans from Italian, as pointed out by Kuen, 1932:139. In this case too, as described in Ballone, 2010, the quality of the mid vowels of Italian loans does not normally follow the *standard* Italian pronunciation as much as the Sardinian Regional Italian pronunciation, which is, in turn, heavily affected by Sardinian metaphony.

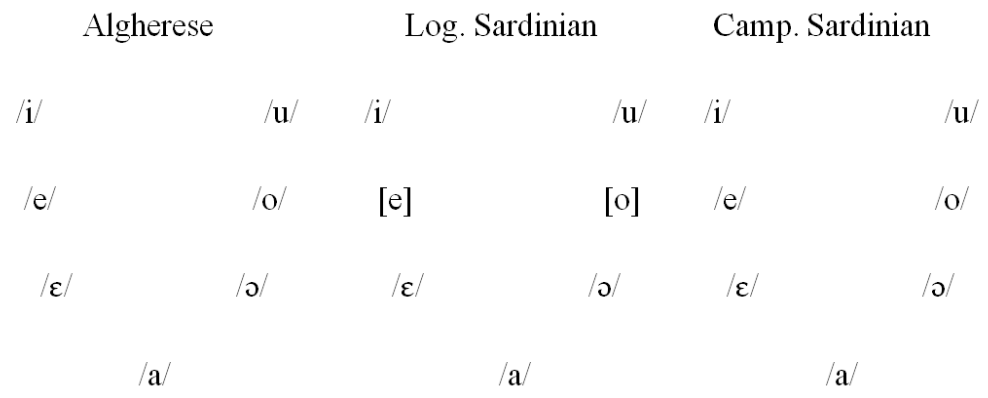


Figure 9: The schematic vowel inventory for Algherese (adapted from Mascaró, 2002) and Logudorese and Campidanese Sardinian (adapted from Jones, 1988). The scheme only concerns stressed vowels and hence does not account for the phonological reduction processes active both in Algherese (for unstressed mid vowels) and Campidanese Sardinian (for unstressed mid vowels in word-final position).[83] It should be added that the stressed vowel inventory of Algherese phonologically coincides with that of the majority of Catalan varieties.

According to the graph, it should not be difficult to demonstrate, even on a perceptually-based approach, that in general the new inhabitants of Alghero managed to learn (for example) the categorical difference between 'd[ɛ]u' ('ten') and 'd[e]u' ('god'), and to correctly reproduce it so as to guarantee the diachronic conservation of that opposition. On the other hand, it is not impossible for some changes to have happened 'below' the phonological level (i.e. at the phonetic level, such as [ɔ] pronounced as [ɔ̯]) and to have partially escaped the normal social censorship towards linguistic innovations.[84]

In the first part of this section some remarks were made on the possibility of immigration having conditioned the diachronic change of Algherese Catalan, perhaps in a more Sardinian-like way; an opposite tendency was also hypothesised, in that the possibility was not excluded that some *conservative* factors (such as the native-like competence in Algherese acquired by the sons and daughters of immigrants born in the city) may have instead contributed to the preservation of the Catalan origin quality of Algherese vowels. Further *innovative* vs. *conservative* dynamics favouring or disfavouring, respectively, linguistic change will be dealt with in the next section in order to make a reliable prediction concerning the acoustic quality of Algherese vowels. In the case where conservative factors are thought to have overwhelmed

[83] See below § 2.3.
[84] This concept will be better dealt with in the next section.

innovative ones, it will be hypothesised that Algherese vowels converge towards Catalan rather than the Sardinian correspondent in the vowel space. By contrast, if the prevalence of innovative factors can be hypothesised, Algherese vowels are expected to be acoustically more similar to their correspondents in Sardinian, and especially to those of Northern Logudorese.

1.6.2 Process of L2 acquisition by immigrants and its possible influence on linguistic change in Algherese

As will be seen throughout this section, many research studies have investigated the factors favouring or disfavouring a complete mastery of an L2 by newcomers. Those studies normally have concerned immigrants individually or in small groups, and deal with a learning process carried out over months, years or (at most) a lifetime. The diachronic and quantitative dimension of these works is rather different from that concerning our study, which deals instead with possible immigration-related linguistic changes affecting the language of a town of thousands of people over a period of several centuries. Nonetheless, it is believed here that the analysis of the data present in the literature on L2 acquisition can help us in predicting the direction of linguistic change concerning the quality of Algherese vowels, and also provide stronger theoretical bases for the interpretation of the results. Testing the possibility that new Algherese inhabitants have somehow adapted, from an acoustic point of view, the L2 vowel system (i.e. that of Algherese) to that of their mother tongue (i.e. Sardinian for most of them), constitutes the first aim of the present thesis.

The main variables considered in the literature to possibly favour the native-like acquisition of an L2 will be interpreted here as *conservative* factors, in that a possible complete mastery of Algherese by (for example) Sardinian-speaking immigrants is expected to play a role in the conservation of the original Catalan quality of Algherese vowels. By contrast, the factors normally said to disfavour the complete mastery of an L2 will be considered *innovative*, in that they are expected to have contributed to accelerating the linguistic change of Algherese in non-Catalan directions, and in particular towards Sardinian.

Following Piske et al. (2001:195–204), a brief list of the variables traditionally said to play a role in allowing a foreigner to master a new language will be given below, and each point will be further discussed in the light of the documents gathered so far about the repopulation of

Alghero and the possible social and economic processes underlying the cultural and linguistic naturalisation of its new inhabitants.

a) Age of L2 learning (AOL)

It is commonly believed that, in general, children are more successful than adults in learning a second language, both in terms of the possibility of acquiring an accent-free pronunciation of the L2 and in terms of struggling less during the learning process.[85] A very important concept in this respect is that of the *critical* period. The Critical Period hypothesis can be summarised with a definition by Piske et al. (2001:194):

> According to the C[ritical] P[eriod] hypothesis, complete mastery of an L2 is no longer possible if learning begins after the end of the putative CP.

Scholars do not always agree on the age over which a learner normally loses the capacity to completely master the L2. Some suggest that the Critical Period starts at the age of 12,[86] or after childhood,[87] or 'not much beyond the onset of puberty in most cases'.[88] On the other hand, the possibility of *late* learners also achieving a native-like accent,[89] where 'late' means *at* and *over* the age of 12, i.e. the age set by Lenneberg (1967) as the end of the Critical Period, cannot be excluded.

When these issues are applied to Algherese immigration on the diachronic axis, it is probably not essential to establish with precision whether newcomers were able to learn this variety of Catalan with no foreign accent at the age of (say) 12 or 13 years, since historical documents rarely report such precise records as the age of arrival, i.e. AOA, which is normally directly linked to the age of L2 learning or AOL. At the same time, historians normally relate immigration to Alghero to the economic opportunities that same city could provide, be it in terms of coral diving, working on the land, services and so on, which makes it not implausible to claim that the majority of the immigrants were already adults at the time of their arrival in the city.[90] According to the Critical Period hypothesis, their possibilities of acquiring a native-

[85] See Bongaerts et al., 1995:30.
[86] See Lenneberg, 1967.
[87] Walsh & Diller, 1981.
[88] See Seliger, 1978:16.
[89] See Flege et al., 1995; Bongaerts et al., 1995; Bongaerts et al., 1997.
[90] See, among others, Manconi, 1994 (especially pp. 357 and 358) and Budruni, 2010b, especially Chapter IX.

like linguistic competence were therefore scarce or null. These conclusions would also apply to the immigrants' partners, whereas higher possibilities can be hypothesised of immigrants' sons and daughters achieving a mastery of L2 (especially the youngest ones), even though it should not be taken for granted that all *early* learners do acquire an accent-free L2, since many of them, and especially those who continue to use their L1 on a regular basis, might still be detected as 'foreigners' by L2 native speakers.[91]

A different discourse applies to the sons and daughters of immigrants born in the L2-speaking territory. Even though they might still present some interference of the L1 spoken in their own families,[92] it is highly unlikely that they would be perceived as foreigners in a city as small as Alghero, where it was physically impossible for children to avoid the horizontal linguistic levelling produced by the full-immersion teaching of Catalan displayed naturally in the 'carrers'[93] ('streets').

From our dichotomic perspective of *innovative* vs. *conservative* linguistic pressure, the post-pubescent or adult AOA of the greater part of the immigrants is certainly an *innovative* element, i.e. a fact which may have contributed, for our purposes, to the acoustic change of the original Algherese vowels. At the same time, the conservative role of immigrants' sons and daughters in possibly contributing to maintaining the original quality of Algherese vowels will be also taken into account.

b) Length of residence

According to Piske et al. (2001:§ 2.2.2) the *length of residence* (LOR) 'specifies the number of years spent in a community where the L2 is the predominant language'. In the same review, it was claimed that 'not every study has shown a significant effect of LOR on degree of L2 foreign accent. In those studies where an LOR effect was found, LOR was a less important predictor of degree of L2 foreign accent than AOL'.[94] Given the fact that the majority of immigrants to Alghero were presumably adults at their AOL, the effects of LOR can be read both as conservative and innovative factors. Conservative, since it does not exclude the possibility that a long-term exposition to the L2 can to some extent help

[91] See Flege et al., 1997.
[92] See Potowsky, 2008.
[93] See Caria, 2006:42.
[94] See Piske et al., 2001:199.

newcomers reduce their foreign accent and, with specific reference to the vowel system, have a better chance of realising vowels more and more similar, acoustically speaking, to those of Algherese. Innovative, since it is unlikely that late learners will acquire a complete mastery of an L2 even after many years spent in the new linguistic community, with the result that they have more time to potentially contribute to changing the L2; this could be especially true in periods in which the demographic weight of recent immigrants was important, such as in the aftermath of the two great plagues of 1582–83 and 1652.[95]

c) Gender

In a study carried out on 71 young Cuban immigrants to the United States, Asher & Garcia (1969) claimed that differences in the degree of foreign accent also depended on the variable 'gender' when the AOL of the informants was between 1 and 12, with better performances in L2 by female speakers.[96] By contrast, when the AOA exceeded 12 years, 'almost as many girls (62%) as boys (72%) had a definite foreign accent' (p. 339). Another factor which seemed to reduce the incidence of the variable 'gender' in modifying the degree of foreign accent was LOR (length of residence), since 'for those children who lived in the United States for 5 to 8 years, the differences in English pronunciation between boys and girls seemed to vanish' (p. 340).

The findings of Flege et al. (1995b:3129-3130) also indicate some possible incidence of the variable 'gender' in the degree of foreign accent, since females were attributed mean higher ratings than males in the production of L2 phrases as a function of an early AOL, whereas males were given higher ratings than females for an AOL of 18 and more.

Both the studies mentioned above are included in the review by Piske et al. (2001), along with other works suggesting instead that the variable 'gender' does not affect the degree of L2 accent (p. 200). In this respect, the authors conclude that '[…] the results obtained for gender do not lead to any strong conclusions. Some studies reported a significant influence of gender, whereas others did not' (p. 200). In the light of this lack of strong evidence that the variable 'gender' generally affects the degree of foreign accent, no strong conservative or innovative

[95] See Budruni, 2010b, Chapters VI and IX.
[96] See Asher & Garcia, 1969:339. Speakers were grouped according to their AOA into three sets: 1 to 6 years of age, 7 to 12 and 13 to 19.

effect should in theory be attributed in the present study to the fact that male immigration has historically outweighed female immigration to Alghero.[97]

From a different perspective, however, it is reasonable to think that 'mothers are traditionally more engaged in raising children than fathers, particularly during the early years of children's language acquisition'.[98] As a consequence, some studies suggest that when differences are detectable in the language spoken by parents, children normally tend to reproduce the linguistic variant used by the mother.[99] In this context, the frequent exogamic weddings celebrated between local women and male immigrants, as historically attested in Alghero by many surviving documents,[100] would suggest a more faithful or conservative transmission of Algherese Catalan to the offspring.

d) Language use

In point 'a)' above, it is stated that the variable 'age of L2 learning' (AOL) is normally considered by scholars to be an important factor in a learner's potential achievement of complete mastery in an L2. At the same time, however, some scholars have pointed out that it is not impossible for some late learners to speak the L2 with native-like competence,[101] and also that a low AOL may not be a sufficient condition for learners to speak L2 in an accent-free manner. In the latter case, as shown in a study by Flege et al. (1997), a possibly important factor causing the foreign accent to be maintained is the more or less frequent use of L1 by learners.[102] The study took into account the linguistic productions of 40 native speakers of Italian who emigrated to Canada between the ages of 2.6 and 9.6, and who had been living in Canada (at the moment of the interview) for at least 18 years. All the speakers, who were bilingual Italian-English, reported that they still used Italian. They were divided into two groups according to their self-reported frequent use (36% on average) or less frequent use (3%) of their L1. As a result, both groups were said to present a detectable foreign accent

[97] In this respect, Budruni (2010b:104) writes: 'L'immigrazione maschile, come appare evidente, è preponderante rispetto a quella femminile, a dimostrazione della domanda imperiosa di 'braccia' in una città che abbisognava di tutto e soprattutto di manodopera' ('It is apparent that male immigration outweighs female immigration, confirming that the need for manual labourers was compelling in a city which was in need of everything, and especially of manpower'). The author is referring to the massive immigration following the great plague that affected Alghero in 1652.
[98] See Potowski, 2008:217, quoting Labov, 1994.
[99] See Potowski & Matts, 2008; Potowski, 2008; Kamada, 1997.
[100] See Budruni, 2010b:103-104 and, for a different view on the quantitative weight of Sardinian immigrants on the total exogamic weddings celebrated in the city in the seventeenth century, Caria, 2006:45.
[101] See Bongaerts et al., 1997.
[102] More results supporting this possibility are provided in Flege et al., 2003.

when speaking English, although 'the native Italian subjects who continued to speak their L1 relatively often […] had significantly stronger foreign accents in English than did the subjects who seldom spoke Italian' (p. 182).

With regard to the sociolinguistic dynamics characterising immigration to the city of Alghero, it is probable that newcomers coming to the city with their families continued to speak their L1 with their partner and/or relatives. Other than that, it is quite probable that all the Sardinian immigrants who worked as farmers and shepherds in the territories surrounding the city walls continued to use their mother tongue on a daily basis (or quite often, at least) with other Sardinian-speaking labourers (see above § 1.5). Hence, it is probable that the frequent L1 use constituted an *innovative* fact for many newcomers, delaying or impeding their complete mastery of L2. The importance of this possibly innovative factor is even more apparent if we consider the relatively high percentage of the population working as farmers or shepherds, which accounted for one-third of the total active male population in 1833 and almost 50% in 1771.[103]

e) Other possible *innovative* and *conservative* factors

The study by Piske et al. also includes such variables possibly affecting the quality of language acquisition as *formal instruction*, *motivation* and *language learning aptitude*. As regards the first variable, it is plausible that the majority of newcomers to Alghero never received 'formal instruction' *in* Algherese or *about* Algherese (it could be useful to remember that mass education in the city is quite a recent phenomenon, and education has always been given *in* Italian and *about* Italian). An exception not to be underestimated – although it should not be considered education in the scholastic sense – was represented by the use of Catalan by the Catholic Church, which lasted (at least for sermons) until the first decades of the twentieth century.[104]

As regards *motivation* and *language learning aptitude*, it is plausible that in some cases highly motivated or skilled immigrants could have achieved a higher L2 competence than

[103] See Day & Calia, 1994:438-439. The percentage for 1771 has been estimated by the two authors by adding to the known percentage of farmers and shepherds (32.6% and 11.4%, respectively) the presumed percentage of the 'vignaioli a tempo pieno' ('full-time vine-dressers').

[104] It is worth pointing out that during the last few decades many efforts have been made to bring back Algherese into the Mass (see http://www.sardegnacultura.it/documenti/7_92_20060703164547.pdf) and to also provide formal instruction in the language. However, the detailed evaluation of the results of these efforts goes beyond the aims of the present study.

immigrants who lacked those qualities, but these effects cannot be reliably evaluated here owing to the lack of direct historical testimony of the average motivation or language skills of the new inhabitants.

It is pointed out above that studies on L2 acquisition normally deal with factors possibly affecting the level of proficiency of a given learner over a span of months, years or – at most – a lifetime. When, however, we attempt to evaluate the possible realisation of Algherese vowels as still phonetically Catalan, due to the prevalence of *conservative* facts, or visibly affected by the L1 of the immigrants, due to the prevalence of *innovative* and Sardinian-oriented facts, this implies a widening of the diachronic perspective to a centuries-long dimension. According to the studies by Bosch,[105] the introduction of Sardinian lexical, phonological and morphological interferences on Algherese[106] was often a gradual process, in which some Catalan origin forms coexisted for a certain period with a correspondent loan from Sardinian, before the latter – as happened in many cases – totally substituted the former. In other cases, the documents studied by the author contained inconsistencies of spelling in the description of the same subject, which are interpreted as ongoing processes of phonetic and morphological change, spreading first over a specific sociolect, and often ending up as generalised innovations.[107] In other words there may also be a balance at a given moment between some conservative tendencies and some innovative ones. In the case of Alghero, it is possible that the constant and centuries-long immigration from (for the most part) other parts of Sardinia, and the simultaneous lack of immigration from Catalan-speaking areas, has allowed some innovations to gain ground and substitute, in the long term, the genuine forms.

Another element which should be included in the current evaluation of the role of innovative vs. conservative factors in the evolution of Algherese is social control over the language. As has happened for other languages, an innovative linguistic phenomenon is often interpreted, at least at its early stage, as a simple 'mistake' to be corrected.[108] Marazzini (2002:148) writes

[105] See in particular Bosch, 2002 and Bosch, 2012.
[106] It should be noted that the author studied historic documents concerning the rural environment, where the linguistic interferences on Algherese are traditionally attributed to Sardinian. As regards linguistic changes attributed to other languages (especially in the maritime environment), see Caria, 1995.
[107] Caria (2006, specially pp. 21 and 53) disagrees with Bosch about the exact period in which such changes were generalised, but both authors (and this is the most salient issue to be pointed out) describe such changes as *gradually* introduced and generalised in Algherese.
[108] In this regard, a very interesting example is the 'Appendix Probi', i.e. a list of 'common errors' presumably compiled by a Roman teacher between the third and sixth centuries AD. In many cases, those 'errors' contained elements of the future vulgar Italian (see Marazzini, 2002:146).

that: '[…] *la lingua è governata da una 'censura collettiva', e solo le innovazioni che superano questa censura possono essere accolte*'.[109] This description does not collide with the obvious consideration that languages do change, as much as it points out the importance of social pressure in presumably reducing the degree of change, and in some cases in preventing some innovations from becoming generalised.[110]

As regards the correct pronunciation of Algherese vowels, it is not hard to imagine the strict linguistic control of the native speakers over the learners, at least at the phonological level. Even today, it is possible (and not uncommon) to hear a native speaker of Algherese firmly correct any youngster who confuses, just to mention one example, the /ɛ/ of '*deu*' ('ten') with the correspondent close-mid phoneme /e/ of '*déu*' ('god').[111] At the same time, the author of the present study, who is a native speaker of Algherese and has lived in Alghero all his life, has never experienced any intervention by a native speaker wanting to correct somebody else due to a modification of a given vowel in *phonetic* terms. In other words, it would be at least 'rare' to hear any Algherese people correcting somebody else for having uttered, for example, an [ɛ̝] (i.e. an open-mid front vowel realised not as open as expected) instead of an [ɛ], or an [o̝] (i.e. a close-mid back vowel realised not as close as expected) instead of an [o]. This means that some changes in a given language might not be perceived by the community of speakers of that language, and consequently their generalisation could be made easier by the fact that they are not censured by the more conservative (linguistically speaking) speakers. In other words, it is possible that the conservative pressure of linguistic censorship is not activated for some specific acoustic changes.

Table 4 summarises the conservative and innovative factors possibly conditioning the acoustic quality of Algherese vowels. The same factors have been evaluated in a manner consistent with the studies on L2 acquisition analysed in the present section and the sociolinguistic and demographic data available for Alghero dealt with in the previous sections.

[109] '[…] language is governed by a 'collective censorship', and only the innovations which go beyond this censorship can be accepted'.
[110] The very 'Appendix Probi' contains examples of 'errors' which did not generalise, since 'Non sempre la forma attestata nell'*Appendix Probi* è quella che ha dato origine agli sviluppi romanzi […]' ('Not in every case the forms attested in the *Appendix Probi* were the ones generating the Romance evolutions […]'). See Marazzini, 2002:147.
[111] It is quite curious that in the case of some words with low frequency of usage, and probably affected by (Sardinian Regional) Italian, such as 'parròquia' and 'història', even native speakers sometimes 'miss' the traditional open-mid timbre of the stressed vowel and pronounce them as the metaphonised [o] (see Ballone, 2010).

Age of L2 learning	innov.	the majority of immigrants were presumably adults at the AOL
	conserv.	immigrants' sons and daughters born in the city presumably acquired Algherese with a native competence
Length of residence	conserv.	longer time to improve their competence in Algherese
	innov.	longer time to possibly introduce elements of their L1 in Algherese
Gender	conserv.	prevalence of male immigration and exogamic weddings with native Algherese women, i.e. prevalence of native Algherese linguistic model (of the mother) in the education of the offspring
Language use	innov.	daily or frequent linguistic contact of many immigrants and natives with Sardinian (and Sassarese) speakers, but also, in the maritime ambit, with speakers of other languages
Constant centuries-long immigration	innov.	in some cases, the balance between conservative and innovative linguistic elements resolved, in the long term, in favour of the latter
Social linguistic control	conserv.(?)[112]	less chance for an innovative linguistic process to generalise

Table 4: Conservative and innovative factors possibly affecting the acoustic quality of present-day Algherese vowels.

As shown in Table 4, both conservative and innovative factors may have affected the acoustic quality of Algherese vowels, and it would not be easy to predict if the latter are still acoustically Catalan or if they have been adapted to the correspondent in the L1 of the newcomers. A factor which could make the *innovative* hypothesis a bit more probable is that, as anticipated earlier in the current section, some strictly acoustic changes in the stressed Algherese vowel system could also have 'escaped' social linguistic control; in other words, it is considered here that it was (and still is) quite unlikely for an immigrant to be censured for uttering, say, a [ụ] with a more advanced tongue body than the expected [u], or an [ɛ̣] realised as more raised than [ɛ], but not as much as an [e]. Another variable which probably counted

[112] The question mark refers to the unclear role, discussed in the previous page, possibly played by 'collective censorship' in preventing historical immigrants to Alghero from pronouncing Algherese vowels in a more Sardinian manner acoustically though not phonologically.

more than others in unbalancing conservative vs. innovative effects in favour of the latter is the constant and centuries-old Sardinian immigration to the city.

1.6.3 Experimental hypotheses

Research works concerning the history of Alghero and its language have indicated that the constant and centuries-long immigration to the city has completely modified the original ethnic composition of its inhabitants, and has also contributed to modifying the variety of Catalan spoken in the city, where an unquestioned pre-eminent role in this process has been played by Sardinian. An effort has been made in the present chapter to understand whether this partial linguistic change may also have affected the acoustic quality of Algherese vowels. Many possibly conservative pressures have been dealt with, i.e. factors that may have contributed to the preservation of the original Catalan quality of Algherese vowels, and also innovative pressures, i.e. factors that may have accelerated the acoustic change of the vowels in question. A general comparison between the two opposite (innovative vs. conservative) pressures suggests that over the centuries the former may have overcome the latter.

Should it be proved that innovative factors have made Algherese vowels phonetically different from the corresponding vowels in other Catalan varieties, the same vowels would be expected to resemble more closely the corresponding vowels in Sardinian varieties, in particular those of Northern Logudorese. On the Catalan side, the documents gathered so far suggest that no reliable prediction can be made of what individual dialect could be expected to present more similarities with Algherese in terms of vowel space location; therefore the mean values of the four major Catalan varieties, extracted from Recasens & Espinosa (2006), will be used in this study as a framework of reference for Catalan.

As will be further explained in Chapter 5, these research hypotheses will be tested, following Oh et al. (2011), in terms both of formant frequency measurements and of vowel duration. Needless to say, if both these measurements give similar results for all three language systems (i.e. Catalan as the mean values of the four major Catalan varieties, Algherese, and Sardinian as the mean values of four Sardinian varieties), the predictions made so far cannot be reliably confirmed or excluded.

Chapter 2

Possible effects of inventory size on the dispersion and variability of Algherese and Sardinian vowels

Chapter two introduces the second aim of the present dissertation, namely the testing of two predictions of the Adaptive Dispersion Theory (ADT) against instrumental data on the stressed vowels from Algherese, Sardinian and other Catalan varieties. A general overview of the ADT is given in section 2.1. Section 2.2 describes the two predictions of the ADT which will be tested in the present study. Section 2.3 includes a general description of the Sardinian vowel system, and section 2.4 is aimed at understanding how the theoretical framework of the ADT can be used to characterise the inventory size of the Catalan and Sardinian varieties under investigation. Finally, section 2.5 presents several experimental hypotheses.

2.1 The Adaptive Dispersion Theory

Liljencrants & Lindblom's 1972 Adaptive Dispersion Theory (henceforth ADT) constitutes an attempt to understand the mechanisms underlying the distribution of vowels in the vowel space and, in so doing, to predict their universal structure as a function of inventory size. A key role in determining the spatial distribution of vowels is played by perceptual contrast, in that vowels are expected to be as contrastive as possible by increasing their mutual acoustic distance. Some assumptions of ADT have changed over time (see Lindblom 1975, 1986) and, consequently, some of its predictions have also changed. Two of these will be discussed in detail in the following sections, and tested in the present study against data from Catalan and Sardinian varieties.

2.2 Two predictions of the Adaptive Dispersion Theory

a) Positive relationship between vowel inventory size and vowel space dispersion

According to Liljencrants & Lindblom's 1972 version of ADT, the distribution of vowels of a given language in the vowel space would take place so as to maximise perceptual contrast. In the authors' words '[…] vowels can serve as more efficient carriers of differences in meaning as they become more dissimilar, and the risk of confusing them decreases'.[113] In other words, this first version of ADT predicts that the vowel phonemes should collocate in the vowel

[113] See Liljencrants & Lindblom, 1972:855.

space so as to present more or less equidistant intervals, in order to allow the maximal perceptual contrast. Consequently, the distribution of vowels will change according to their increase in number in a given system, until the same system reaches an equilibrium. The assumption justifying such an 'optimised' distribution of vowels in the vowel space is that vowels should be treated analogically to 'particles with an equal electrical charge', repelling each other until 'equilibrium is reached where their distance cannot be increased any more' (p. 841).

The ADT[114] prediction of vowel distribution was tested by the two authors by comparing the output of a computer implementation of their model with some descriptive and impressionistic data on the spatial distribution of vowel phonemes in several languages. As a result they claimed that the ADT predictions were found to be 'approximately correct' with regard to three-, four-, five- and six-vowel systems. For more crowded vowel inventories, some major discrepancies were found instead, such as the tendency for the model to overproduce high-central vowels such as [ɨ] and [ʉ]. A first modification of the ADT was proposed by Lindblom in 1975 on the assumption that, if the distribution of vowels in a given system is supposed to maximise perceptual contrast, more weight should be given to F1 than to F2, since the former formant is more intense and hence prone to cause vowels to become perceptually different. As a result, the modified model generated predictions with a reduced number of high vowels along the fronting dimension, and, consequently, presenting less discrepancies with actual seven- to nine-vowel inventories.

A further development of ADT was proposed by Lindblom in 1986 by substituting the concepts of maximal perceptual contrast and maximal dispersion with those of sufficient perceptual contrast and sufficient dispersion. The most salient implication of this theoretical change is that vowels are no longer expected to present maximal acoustic distances in a fixed vowel space, but, conversely, the expansion of the vowel space is expected to be positively correlated with the size of the vowel inventory, i.e. larger vowel inventories should present a more peripheral vowel location than smaller inventories. In recent years this prediction has been tested by different research studies providing contradictory evidence of its validity. In a study carried out on 28 languages with differently crowded vowel systems, Livijn (2000) did not find any clear positive correlation between inventory size and the Euclidean distances for

[114] Called 'LS' or Lindblom & Sundberg Model in Liljencrants & Lindblom, 1972.

the point vowels /i/, /a/ and /u/, at least in the case of inventories with seven phonemes or less.[115] Similarly, results from other studies have challenged the hypothesis that larger vowel inventories necessarily lead to larger vowel spaces (see Bradlow, 1995; Recasens & Espinosa, 2006; Gendrot & Adda-Decker, 2005), whereas others have found this relationship to hold (Jongman et al., 1989; Al Tamimi & Ferragne, 2005). Among the latter, it is worth mentioning Becker-Kristal (2010), where acoustic vowel dispersion is analysed for 304 languages/varieties.

b) Inverse relationship between vowel inventory size and vowel variability

In the 1972 version of ADT the principle of maximal acoustic contrast was justified by the assumption that vowels could be 'more efficient carriers of differences in meaning' as long as they were 'more dissimilar'. In the 1986 version of ADT, the need for vowels to maintain distinctiveness was to an extent preserved by assuming that large vowel inventories should exhibit less intra-vowel variability. In Lindblom's words: 'Suppose that sufficient contrast does operate in real systems and that it tends to be invariant across languages and system sizes. It follows from this that the phonetic values of vowel phonemes should exhibit more variation in small than in large systems' (p. 33).

This hypothesis is consistent with Manuel & Krakow (1984), for whom '[…] in general, languages with fewer vowels vary more as a function of vocalic context than languages with larger vowel inventories' (p.77), in agreement with the assumption that '[…] languages with fewer vowels can allocate more space to each vowel area than languages with larger vowel inventories' (p.69).[116] By contrast, Recasens & Espinosa (2009) found that mid vowels were not clearly more variable in smaller vowel systems (i.e. those presenting five and six vowel phonemes) than in larger ones (i.e. those presenting seven vowel phonemes).

With regard to these two predictions of ADT, i.e. that richer vowel inventories should present a) *larger vowel spaces* and b) *smaller vowel variability* than less crowded systems, it is believed here that some interesting information might come from the comparison of Algherese and Sardinian varieties, since differences in terms of contrastive vowels can be

[115] In fact, the author found a possible influence of inventory size on vowel expansion for languages presenting eight vowel phonemes or more, but the reduced number of such systems in his corpus did not allow drawing strong conclusions either in confirming or refuting ADT for more crowded inventories.
[116] See also Manuel, 1990.

found among them. As anticipated in the previous chapter, the Algherese vowel inventory presents the seven phonemes /i/, /e/, /ɛ/, /a/, /ɔ/, /o/ and /u/, whereas the northern Sardinian varieties (Nuorese, Common Logudorese and Northern Logudorese) only exhibit the five vowel phonemes /i/, /ɛ/, /a/, /ɔ/ and /u/. In the case of Campidanese, the vowel system has undergone a further evolution with respect to the northern varieties, in that a process of phonological vowel reduction affecting unstressed mid final vowels has made it possible for this variety to create minimal pairs on the basis of the opposition /e/ vs. /ɛ/ and /o/ vs. /ɔ/.[117] Fig. 10 displays the phonological inventories of Algherese, Logudorese and Campidanese, including the diachronic changes of the latter system from time T1 to time T2.

As clearly emerges from the graph, no relevant diachronic changes have affected the inventories of Algherese and Logudorese, whereas Campidanese has shifted from an original Logudorese-like pentaphonemic inventory to a heptaphonemic one.

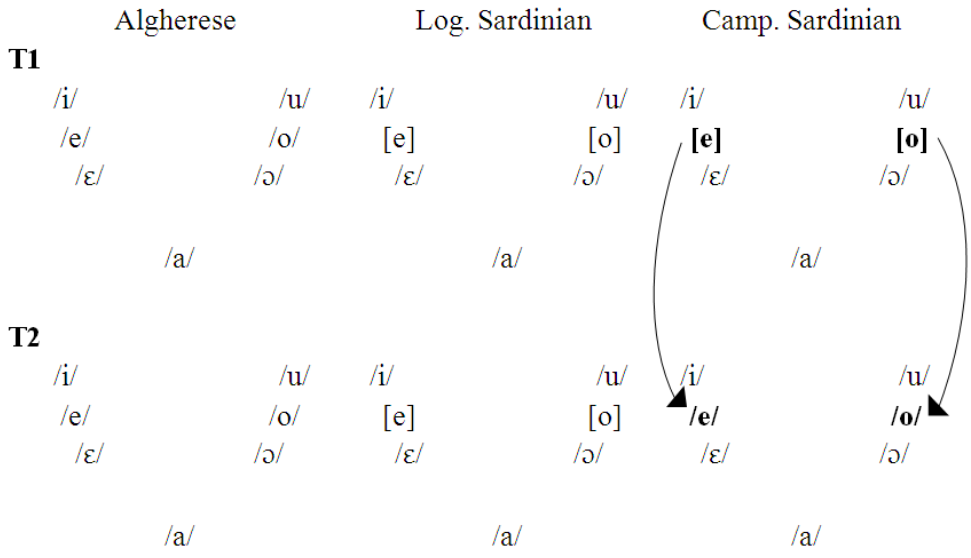


Figure 10: Schematic presentation of the vowel inventories of Algherese, Logudorese and Campidanese on a diachronic dimension. T1 (Time 1) indicates the structure of the vowel inventories of the three systems at a given time T, and T2 a later evolutionary stage of the same systems, i.e. their current structure. The rounded arrows indicate the only diachronic structural changes visible across the three systems.

Before evaluating the possible consequences of these diachronic structural changes in Campidanese in terms of vowel dispersion and variability, some details will be added on the

[117] This process will be dealt with more in detail in § 2.3.

general functioning of Sardinian vowels, particularly mid vowels, and about the factors that have caused the Campidanese system to increase its number of contrastive vowels.

2.3 Elements of the Sardinian vowel system and metaphony

As will be seen throughout this section, the diachronic evolution of the Campidanese vowels presented above in Fig. 10 contributed to creating in the same variety some minimal pairs on the basis of the opposition /ɛ/ vs. /e/, and /ɔ/ vs. /o/, and this is the reason why the majority of scholars nowadays considers Campidanese to have seven vowel phonemes. In this respect, it should be also said that some researchers do not agree with this view (Bolognesi, 1998/2012; Frigeni, 2002), and prefer to consider the Campidanese vowel system as still presenting five vowel phonemes, analogously with Logudorese. In this respect, a brief excursus on the origin and the evolution of the Sardinian vowel system can shed light on the two different views mentioned above.

The Sardinian stressed vowel system comes from a '*conguaglio in un unico esito di ciascuna vocale breve e lunga* [from Latin]',[118] as shown in Fig. 11 (Marazzini, 2002:158).

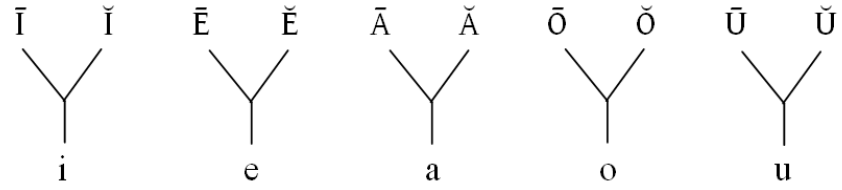


Figure 11: Sardinian adaptation of the Latin vowel system (extracted from Marazzini, 2002:158).

It should be noted that in another table describing the Italian vowel system, Marazzini uses the graphemes 'è' and 'ò' to indicate, respectively, the open-mid front and open-mid back vowels, and 'é' and 'ó' to indicate their close-mid correspondents. The choice of the written accent is not accidental, since it follows the Italian orthographic tradition by which the grave ' ` ' and the acute ' ´ ' diacritics indicate, on mid vowels, an open and close quality respectively. By contrast, no diacritics appear in that study on Sardinian mid vowels,

[118] 'a fusion into just one segment of each short and long vowel [from Latin]' (Marazzini, 2002:158). See also Contini, 1987:435-437.

suggesting that their quality was not an issue the author was specifically dealing with. In this respect, a similar scheme from Contini (1987:437) clearly suggests that both Latin Ē, Ĕ and Ō, Ŏ became in Sardinian, respectively, the open-mid vowels /ɛ/ and /ɔ/, as shown in Fig. 12.

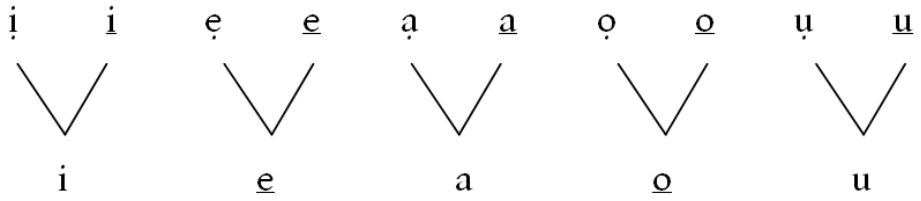


Figure 12: The Sardinian vowel system (adapted from Contini, 1987:437). It should be noted that Sardinian mid vowels are reported as open-mid; in fact, the author uses the dot '.' and the underscore '_' below each vowel to indicate, respectively, their close-mid and open-mid quality.

On the other hand, as all linguists who have dealt with Sardinian know, mid vowels can be also pronounced as close-mid, as reported by Campus (among many others):

> […] esse sono *chiuse* quando la sillaba seguente contiene una vocale di suono oscuro (cioè *i*, *u*, oppure un altro *ẹ* ed *ọ*, chiusi alla lor volta per l'influenza d'un *i* o d'un *u* posteriore); sono *aperte* in ogni altro caso.[119]

This phenomenon is known as (Sardinian) metaphony, and it has been described in similar terms, though with some differences, by Spano,[120] Wagner,[121] Paulis,[122] Contini [123] and many others authors. Given the fact that the degree of opening of a mid vowel is said to strictly depend on contextual features, an obvious consequence is that [e] and [ɛ], and [o] and [ɔ], can only be found in a complementary sense, i.e. they would never create minimal pairs. This is the reason why scholars agree on the fact that Logudorese Sardinian only has five vowel phonemes: /i/, /a/, /u/ and the two mid vowels 'e' and 'o', independently of their context-dependent open-mid or close-mid quality.

[119] '[…] they [i.e. mid vowels] are *close* when the following syllable contains a vowel with a dark sound (i.e. *i*, *u*, or another *ẹ* and *ọ* raised, in turn, by the influence of a following *i* or *u*); they are open in any other case'. See Campus, 1901:16. This explanation implies that when a mid vowel is not directly followed by a close or a close-mid vowel, such as in 'c[ɔ]nn**adu**' ('brother-in-law'), metaphony is not activated.
[120] See Spano, 1840:5.
[121] See Wagner, 1941/1984:31.
[122] See Paulis, 1984:XXII.
[123] See Contini, 1987:439, 442.

When scholars need to describe these mid vowels phonologically, they do not seem to use commonly shared graphic representations. For example, Contini describes the open-mid and close-mid vowels as '[…] *des variants de deux phonèmes uniques (respectivement /e/ et /o/)*[…]'.[124] Contrary to what it may be thought if /e/ and /o/ are interpreted following the IPA transcription system, for Contini the symbols in question do not stand for the close-mid vowels /e/ and /o/ as much as for a 'neutral' graphic representation of mid vowels (i.e. they are not intended to indicate either their open-mid or their close-mid quality).[125] Blasco Ferrer, by contrast, prefers to represent front and back mid vowels with, respectively, the symbols /E/ and /O/,[126] whereas Jones (1988:Table 9.1) clearly considers the mid-vowel phonemes to be /ɛ/ and /ɔ/,[127] adding in his description that the same phonemes may be raised as a result of the metaphony process (p. 317). This last choice would also be consistent with both the definition suggested by Campus (see above) and Fig. 12 (extracted from Contini, 1987), in that Sardinian mid vowels are considered as being naturally open-mid, i.e. they are so unless they undergo metaphony.

In Campidanese, the rule of Sardinian metaphony seems, at first sight, to present many lexical exceptions, such as '*oru*' ('gold'), normally uttered as [ˈ**ɔɾu**],[128] with the mid vowel pronounced as open-mid in spite of being followed by the close vowel [u]. Scholars do not in fact consider this and other similar examples to be simply exceptions to metaphony, as much as the result of a process specifically characterising Campidanese, i.e. a phonological process of vowel reduction by which final /ɛ/ and /ɔ/ become, respectively, [i] and [u]. With regard to '*oru*', its original Campidanese pronunciation was [ˈ**ɔɾɔ**], and the raising pressure normally activated by the final close vowel (in this case: final [ɔ]→[u]) is not activated in this and other similar examples precisely because 'i' and 'u' are non-etymological, as reported by Wagner (1941/1984:31). Where 'i' and 'u' are etymological, they operate instead as a metaphonic trigger in every Sardinian variety, Campidanese included. For example, if we consider the word '*oru*' ('brink', 'edge'), etymological [u] causes the preceding mid vowel to raise both in Logudorese and in Campidanese: [ˈ**oɾu**]. As a result, and unlike what happens in Logudorese, where open-mid and close-mid normally depend on contextual factors and cannot create

[124] '[…] variants of two specific phonemes (/e/ and /o/, respectively)'. See Contini, 1987:453.
[125] In fact, as shown above in the current section, Contini specifically indicates the close-mid quality of a mid vowel with a dot below the vowel grapheme, and an open-mid vowel with the underscore.
[126] See Blasco Ferrer, 2010:96.
[127] See also Grassi et al., 1997:94.
[128] See Virdis, 1978:26.

minimal pairs, in Campidanese there can actually be minimal pairs like [ˈ**o**ɾu] (‘edge’) and [ˈ**ɔ**ɾu] (‘gold’), implying that in this variety [o] and [ɔ] possess a distinctive function. Similarly, minimal pairs can be found among Campidanese mid-front vowels, such as [ˈb**e**ni] (‘come’) – [ˈb**ɛ**ni] (‘well’, ‘good’, originally [ˈb**ɛ**nɛ]), also due to the combination of metaphony and phonological reduction. For all these reasons, many scholars normally consider the Campidanese vowel system to be heptaphonemic: /i/, /e/, /ɛ/, /a/, /ɔ/, /o/, /u/.

By contrast, other authors (Bolognesi, 1998/2012; Frigeni, 2002) prefer to consider the reduced realisation of final [i] and [u] in Campidanese as the mere surface realisations of underlying /ɛ/ and /ɔ/, respectively. This theoretical approach implies that realisations such as Campidanese [ˈ**o**ɾ**u**] and [ˈ**ɔ**ɾ**u**] can be considered the surface realisation of, respectively, /ˈ**o**ɾ**u**/ and /ˈ**ɔ**ɾ**ɔ**/. The last pair would not obviously constitute a minimal pair on the basis of the opposition /ˈo/ – /ˈɔ/, since the final vowels should also be considered different phonemes, i.e. /u/ and /ɔ/, respectively. As a consequence, Campidanese [o] and [ɔ] are not dealt with, in this view, as distinct phonemes. The same analytical procedure can be also applied to [e] and [ɛ], which are thus considered to be two allophones of /ɛ/. In sum, in this view the phonological vowel inventory of Campidanese equals that of Logudorese, with five vowel phonemes: /i/, /ɛ/, /a/, /ɔ/, /u/, and the two dialects share the typical metaphonised realisations [e] and [o] of the open-mid vowel phonemes.

Contini & Boë (1972) do consider Campidanese to have a heptaphonemic inventory, but at the same time acknowledge that the oppositions /e/-/ɛ/ and /o/-/ɔ/ have a very low productivity, since the minimal pairs created by these oppositions are ‘*extrêmement rares*’ (p. 183), and that, a part from these exceptions, the vowel system of Campidanese, along with that of Logudorese, is ‘*strictement conditionné par l’harmonie vocalique*’.[129] All these considerations will be of a great importance in the evaluation of the possible role of vowel inventory size in affecting the degree of dispersion and variability for the Sardinian vowels.

2.4 Adaptive dispersion and vowel inventory size in Catalan and Sardinian

Regarding the validity of the two ADT predictions dealt with in the previous section, Sardinian varieties seem to possess very interesting characteristics in terms of phonological

[129] ‘strictly conditioned by vowel harmony’ (p. 183). It should be noted that the authors use ‘vowel harmony’ as a synonym of ‘metaphony’.

crowdedness. On the basis of a more synchronic and contrastive-based approach, the pentaphonemic Logudorese variety undoubtedly differs from the more crowded heptaphonemic Campidanese one. At the same time, the vowel allophonic distribution in those two macro Sardinian varieties appears not to differ from, *inter alia*, a typical heptaphonemic inventory such as that of Algherese (and also of other Catalan varieties), as shown above in Fig. 10. Moreover, if a more etymologically-based approach is adopted (such as that proposed by Bolognesi and Frigeni) the phonological inventories of the two systems would be reduced to five vowel phonemes each. In what terms should ADT be tested?

In this respect, Liljencrants & Lindblom (1972) made it clear that any changes in vowel variability and dispersion should only be attributed to differences in the number of 'vowel phonemes',[130] and hence, following a strict version of ADT, the more crowded Campidanese inventory (with seven phonemes) should present more dispersed and less variable vowels than the less crowded one of Logudorese (with five phonemes). Similarly, with specific regard to vowel variability, Manuel & Krakow (1984) suggest that vowel-to-vowel coarticulation should be related to the number and distribution of *contrastive* vowels in a language, due to the '[…] necessity of maintaining distinctiveness' which 'is defined for each language in its phonology' (p.77). A partial support for this view is given by Manuel (1990), who compares the effect of inventory size on contextual variability in languages presenting the same number of contrastive vowels seen for Logudorese (five) vs. Campidanese (seven) and Algherese (seven). The three languages investigated by Manuel (all belonging to the Southern Bantu family) were Shona and Ndebele (/i, e, ɑ, o, u/), and Sotho (/i, e, ɛ, ɑ, ɔ, o, u/), the latter presenting a richer phonological inventory in the mid regions. Her results partially confirmed the possibility of vowel variability being inversely proportional to vowel inventory size, in that the low vowel /ɑ/ proved to be more contextually resistant in Sotho than in Shona and Ndebele, possibly because in the latter systems the risk is lower for the low vowel to be confused with mid vowels, since the inventory lacks /ɛ/ and /ɔ/. The author is, however, cautious about drawing general conclusions on the predictive power of the variable 'inventory

[130] See Liljencrants & Lindblom 1972, § 2.3. Furthermore, in the same section the authors make it clear that their definition of vowel phonemes does not include underlying phonological vowels. Hence the possibility claimed by Bolognesi and Frigeni of considering the Campidanese inventory as pentaphonemic due to the difference between *surface* representations and *underlying* vowel phonemes should not have any influence on the ADT prediction, since Campidanese clearly has seven contrastive vowels, and, regardless of their possible status as 'surface representations', these seven vowels are the only framework of reference considered by ADT.

size' in expecting higher or lower vowel variability. In fact, the other vowel under analysis, /e/, proved not to vary much across the three systems.[131]

As anticipated above in § 2.1, contradictory evidence is provided in the literature on the two ADT predictions of interest in the present study. As regards Sardinian varieties, no studies dealing with the relationship between variability and inventory size have been found by the author of the present work. On the other hand, exploratory instrumental data available in Contini (1987:449) can allow a first testing of the ADT prediction about the positive relationship between vowel inventory size and vowel dispersion, since the author presents formant data for vowels belonging to three Sardinian dialects differing in the number of vowel contrasts, namely Northern Logudorese (five), Nuorese (five) and Campidanese (seven).[132] From the data, expressed in Hz, it was possible to compute the area encompassed by the point vowels /a, i, u/ in each variety.[133] As a result, the most dispersed point vowels turned out to be those of the two pentaphonemic varieties (i.e. Nuorese and Northern Logudorese), while the smallest area was obtained for Campidanese, in plain contradiction to ADT and Manuel & Krakow's prediction. When the vowel spaces were computed as the mean value of the distances of each vowel from the 'centroid' or 'grand mean',[134] the Campidanese vowel space turned out to be greater than that of the Northern Logudorese correspondent, but still smaller than that of Nuorese.[135] These results are cautiously accounted for here not as a possible tendency for smaller inventories to be more dispersed, but as a lack of a clear positive relationship between richness in the number of vowel phonemes and a more dispersed vowel space.

A possible problem in using these exploratory results in order to confirm or refute the ADT prediction on vowel dispersion is that Contini's study does not include detailed information on the consonantal environment surrounding target vowels in the different diatopic

[131] This outcome was accounted for by the author assuming that specific consonants flanking the target vowel might also contribute to conditioning the direction and the degree of coarticulation. Another factor claimed by the author to possibly reduce the degree of coarticulation is the requirement to maintain intelligible speech.
[132] The towns of investigation are Nughedu San Nicolò, Orani and Sanluri, respectively.
[133] The areas were calculated (in Hz) with Heron's formula $T=\sqrt{s(s-a)*(s-b)*(s-c)}$ where T stands for the area of the triangle, s stands for the semi-perimeter and a, b, c, stand for each side length. The same areas amounted to 301596 for Northern Logudorese, 356858 for Nuorese and 211746 for Campidanese.
[134] The formula will be described in detail below in § 5.6.1.3. The only difference between the 'reduced' formula used for the present calculation and the 'complete' one proposed in § 5.6.1.3 is that the 'reduced' version only contains one pair of frequency values (F1, F2) for each vowel, whereas the 'complete' one contains instead three pairs of F1xF2 values for each vowel corresponding to the three consonantal contexts described below in § 5.3.
[135] The mean distance from the centroid, measured in Hz, amounted to 492 for Northern Logudorese, 543 for Nuorese and 523 for Campidanese.

pronunciations of each target word. In fact, the same word can present important phonetic differences from one Sardinian dialect to another, such as in 'deghe/dexi' ('ten'), pronounced in the northern varieties as [ˈdɛɣɛ]/[ˈdɛkɛ], with stressed [ɛ] followed by a velar consonant, and in Campidanese as [ˈdɛʒi], with target [ɛ] followed by a palatal consonant instead. In this respect, studies from the literature have shown that among the factors conditioning the realisation of a given vowel is coarticulation by adjacent segments, with the presence of visible phenomena of *undershoot*[136] even in the stressed domain. In Recasens & Espinosa (2006), for example, data are reported for stressed Catalan vowels presenting clear formant frequency variations as a function of the place of articulation of the flanking consonants. Differences in the degree of coarticulation were also found to depend on other factors such as the direction of the shift (vowels were more affected in the F2 dimension than in the F1 dimension) and the type of target vowel (front vowels were much more resistant to context-dependent variation than back vowels and /a/). As shown in the same study (especially in the lower graph of Fig. 7), a joint consideration of these differences in degree of coarticulation reveals that target vowels flanked by labial consonants are more dispersed than is the case for the corresponding vowel realisations in the dentoalveolar and, particularly, palatal contexts. These findings suggest that overall space dispersion might also depend on contextual factors, with two important implications. First, in evaluating the degree of vowel expansion it is advisable to try to isolate somewhat the variable 'context'; secondly, data by Contini can be taken as a first clue that vowel system expansion may not be proportional to vowel system size among Sardinian varieties, but, at the same time, this claim has to be taken with caution, since no clear information is available in that study about the possible effects of coarticulation on vowel realisation and, indirectly, about the distribution of vowels in the vowel space.

2.5 Experimental hypotheses

The remarks made so far concern a strict interpretation of the definition given by Liljencrants & Lindblom (1972) of vowel inventory as being composed of contrastive vowels. However, if we go back to Fig. 10 above, it seems reasonable to question whether the presence of a limited number of minimal pairs in Campidanese in a specific moment of it history (on the basis of the contrast between /ɛ/ and /e/ and between /ɔ/ and /o/) is sufficient to create a need for more perceptual contrast and a consequent enlargement of the vowel space. Moreover, it

[136] This issue will be dealt with in detail in Chapter 3, specially for unstressed vowels.

could be interesting to verify whether or not this phonological enlargement increases the capacity for each vowel to tighten its allophones or, in other words, to become less variable.

In view of the above, the two predictions of ADT dealt with in § 2.2 will be tested in three different ways.

The first will strictly concern the contrastive-based approach indicated by Liljencrants & Lindblom (1972). In this respect, the dispersion and variability of the vowels belonging to the pentaphonemic inventories of Common Logudorese, Nuorese and Northern Logudorese will be compared to the corresponding phenomena in the heptaphonemic inventories of Campidanese and Algherese. Additionally, the results gathered in our experiments will be further compared to the corresponding results for the Catalan varieties given in Recasens & Espinosa (2006), specifically with regard to the three heptaphonemic inventories of Western Catalan, Eastern Catalan and Valencian, and the octaphonemic equivalent in Majorcan.

The second method of testing the ADT predictions (the 'five-phoneme approach') will take into account the claim of some authors that the number of vowel phonemes in Campidanese (i.e. five) should be equivalent to that of Logudorese. In this respect, Sardinian varieties are expected to present, on average, a lower degree of dispersion and a higher degree of variability than the heptaphonemic Catalan varieties, and especially Majorcan, which exhibits eight vowel phonemes.

The third method of testing the ADT predictions (the 'seven-phoneme approach') will consider instead the normal allophonic distribution of Sardinian varieties, which according to the perceptually-based descriptions available in the literature is seen not to differ from a typical heptaphonemic inventory, such as that of Algherese and the majority of Catalan varieties (and also that of Standard Italian and other languages[137]). In this respect, the four Sardinian varieties are expected to present similar degrees of dispersion and variability as the Catalan varieties, with the exception of Majorcan, which is expected to present the most dispersed and least variable vowels, since it has eight phonemes in its vowel inventory.

[137] See Becker-Kristal, 2010:7.

Chapter 3

Unstressed mid vowel reduction in Sardinian

Chapter three introduces the third aim of the present dissertation, namely the evaluation of the effect of acoustic vowel reduction on the realisation of Sardinian unstressed mid vowels. Section 3.1 presents a brief introduction to 'acoustic' and 'phonological' vowel reduction, and also deals with two theoretical models concerning vowel reduction referred to in the present work as the undershoot-based model and the centralisation-based model. Section 3.2 presents a brief review of the variables considered in the literature to cause and enhance vowel reduction. Section 3.3 includes some preliminary formant frequency data on Sardinian stressed and unstressed vowels, and presents the experimental hypotheses.

3.1 Brief introduction to 'acoustic' and 'phonological' vowel reduction

In phonology, *vowel reduction* normally refers to the process of neutralisation of vowel phonemes in unstressed position, with a consequent loss in the number of unstressed vis-à-vis stressed vowels. For example, the stressed vowel system of Eastern Catalan is richer (/i, e, ɛ, a, ɔ, o, u/) than its unstressed correspondent (/i/, /ə/, /u/), as a consequence of the reduction of stressed /a, e, ɛ/ to [ə], and of /o, ɔ/ to [u]. Reduction also affects vowels which are typically pronounced in unstressed position even though they may occasionally exhibit some degree of stress prominence, as for example when bearing an emphatic or secondary sentence stress. In other words, in Catalan the phonological vowel reduction process depends mainly on *lexical* stress, regardless of accidental changes in the degree of prominence for normally unstressed or stressed vowels. That is why, in some cases, the phonological characteristics of a given vowel may be preserved even when the same vowel loses the primary stress in a compound word, such as in '[ɔ]brellaunes' ('can opener').[138]

In Campidanese, too, the mere presence/absence of lexical stress is not the only variable causing phonological reduction. In fact, as seen in the previous chapter, the requirement for a vowel to be reduced in that system is the lack of lexical stress *and* it being in word-final position. In Fig. 13 some examples are given of phonological vowel reduction processes in Catalan and Sardinian.

[138] See Mascaró, 2002:93.

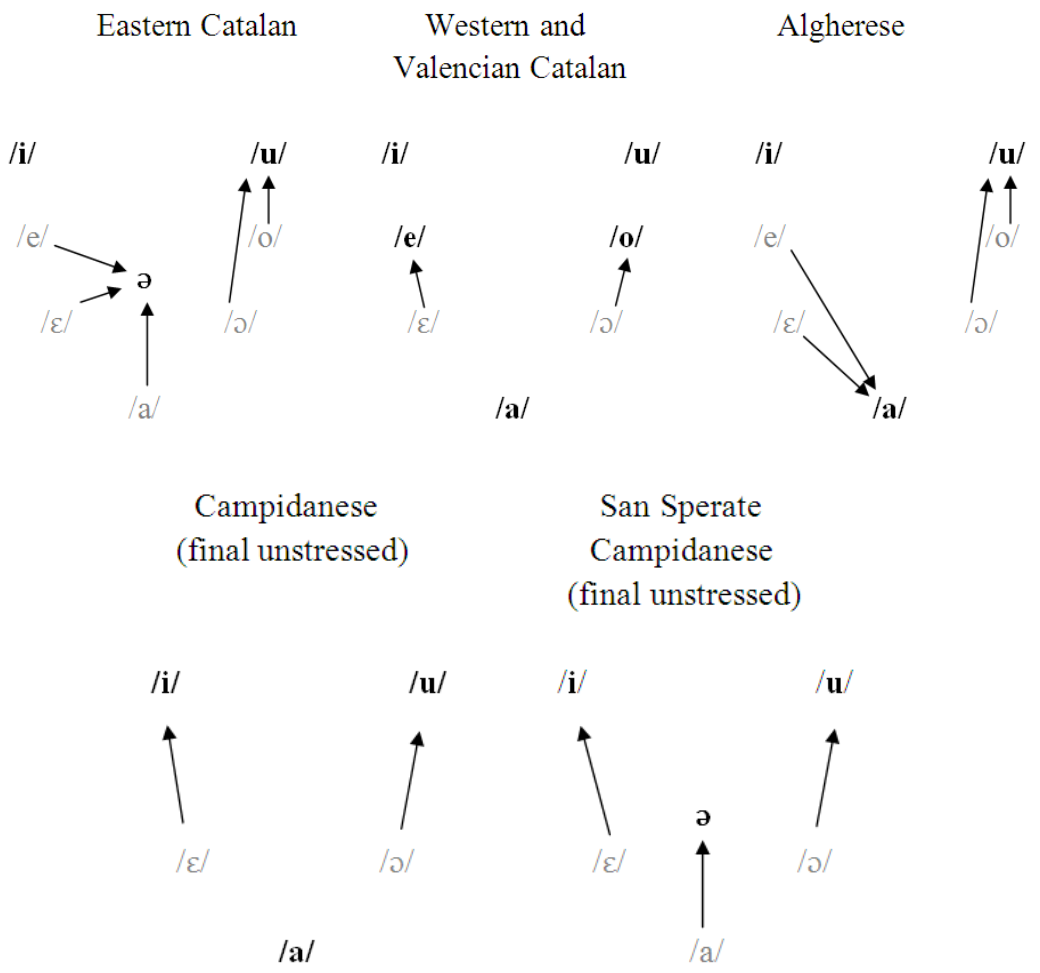


Figure 13: Examples of vowel reduction for Catalan (top) and Sardinian (bottom) varieties. The former systems were adapted from Mascaró (2002), and the latter from Virdis (1978) and Cossu (1997/2009), respectively. The reduced inventories are shown in bold characters and the vowels undergoing reduction are shown in grey.

Many studies have dealt with the mechanisms possibly causing phonological reduction. Much attention is normally paid, at the phonetic level, to the articulatory processes causing a vowel not to reach its canonical or *target* position. In 1963 Lindblom published his well known spectrographic study of vowel reduction, in which the phenomenon of *target undershoot* was instrumentally studied. Vowel undershoot refers to the possibility of articulators not reaching the intended pronunciation, or the vowel *phonological target*, due to some constraints causing physiological limitations such as rate of utterance and coarticulatory effects. According to Lindblom 1963, vowel undershoot can be explained in mechanical or physiological terms, the primary cause of 'articulatory imprecision or laxness' being 'timing' (p. 1780). In Lindblom's words 'As a vowel becomes shorter […] the speech organs fail, as a result of physiological

limitations, to reach the positions that they assume when the vowel is pronounced under ideal steady-state conditions' (p.1779).

In later works, Lindblom partially revises his model, including the possibility that undershoot can (in principle) be avoided through an increase in articulatory effort: 'Compensation for rapid timing of the force commands can be achieved by increasing movement velocities which in turn is brought about by increasing force amplitudes', hence 'we should expect [the speech system] to undershoot phonetic targets quite often, but not necessarily in every single instance. The key point is: **Speakers have a choice**' (Lindblom, 1990). On the one hand, the mechanical constraints causing undershoot are still considered by the author to be an important part of acoustic reduction, but, on the other, it is acknowledged that certain diaphasic-related variables such as speech style can to a certain extent reduce, and even neutralise, undershoot effects.

Prior to Lindblom's 1963 undershoot model, acoustic (or 'phonetic') reduction was normally regarded as the simple convergence of unstressed vowels towards the schwa region in the vowel space, and consequently the very definition of vowel reduction actually coincided with that of *centralisation*.[139] In Lindblom's view, centralisation is seen as a byproduct of coarticulation, and a schwa-like reduced vowel is predicted to occur when 'its immediate context contains schwa elements' (1963:1780). Hence, schwa-like phonetic reduction is still possible, although not as an 'intrinsic propensity of vowels to degenerate into schwa when they occur in connected speech' (1963:1781), but rather as one of the possible outcomes of coarticulation. A clear difference between the two models (the undershoot-based model, henceforth UBM, and the centralisation-based model, henceforth CBM) should be more visible during a rapid realisation of close vowels, in that they are predicted to be less peripheral both in the horizontal (F2) and the vertical (F1) dimensions by CBM, whereas UBM predicts that specific consonantal contexts such as /b-/ and /d-/ would prevent close vowels from being uttered in a more open manner.[140]

[139] See, among other, the description given by Stetson, 1951 (quoted by Lindblom, 1963): 'With the increase in rate all vowels in unstressed syllables arrive at the common schwa'. It should be added that some authors still prefer to consider 'vowel reduction' a synonym for 'centralisation' (Van Bergem, 1993; Van Son, 1993).

[140] According to Lindblom (1963:1777) the vowel transitions right after the release of the plosives /b/ and /d/ account for the presence of a F1 frequency of 375 Hz at the onset of the following vowel, which may as well be close to (or at most slightly lower than) a typical F1 for /u/ and /i/.

Fig. 14 represents the typical patterns of acoustic vowel reduction predicted by the two models discussed so far. Figure 14(a) is an adaptation of the CBM to a typical heptaphonemic inventory with the point vowels /i, a, u/ and the mid vowels /e, o, ɛ, ɔ/. Figure 14(b) was extracted by Flemming (2005), who in turn adapted the undershoot model by Lindblom (1963).

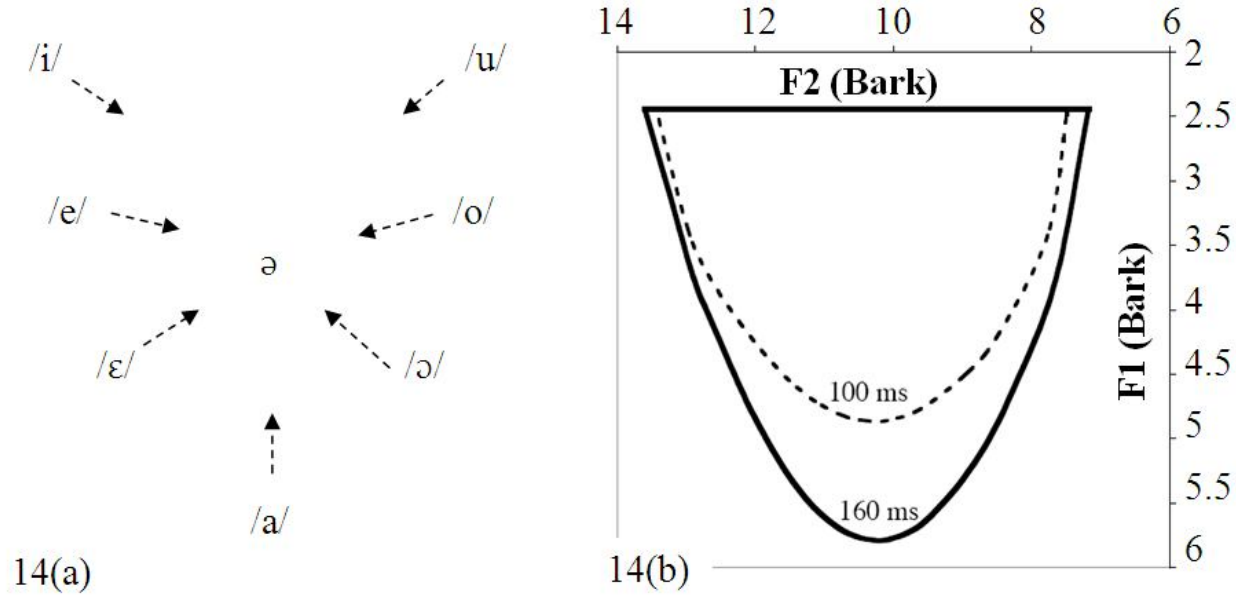


Figure 14: Comparison of two models of acoustic reduction. On the left, the predicted reduction pattern using CBM (centralisation-based model) and, on the right, using UBM (undershoot-based model). The former was adapted here to a seven-vowel inventory such as that of Campidanese and the major Catalan varieties, while the latter was extracted from Fig. 4 by Flemming (2005) (adapted, in turn, from Lindblom, 1963). In Flemming's graph the solid line marks the boundary of the space for vowels 160 ms long and the dashed line marks the boundary of the space for vowels 100 ms long (Flemming, 2005, p. 12).

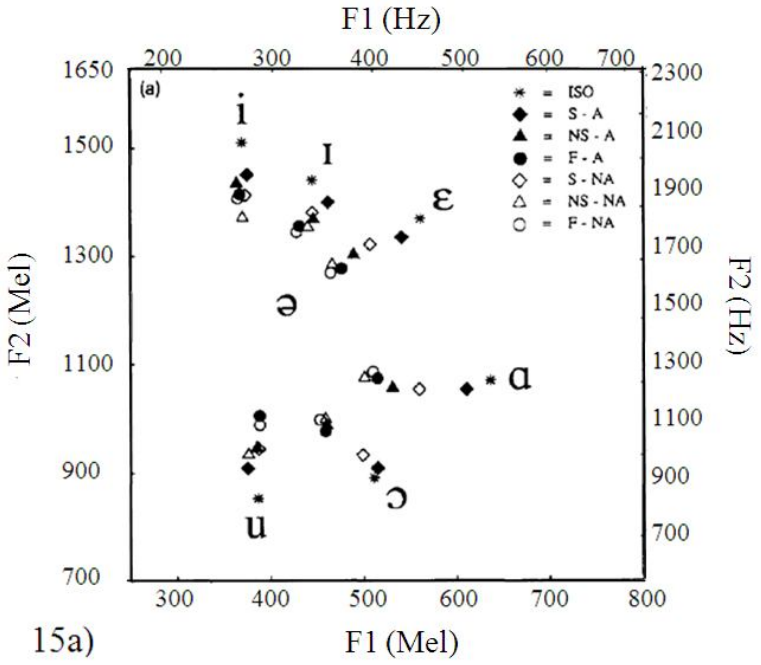
The two models presented in Fig. 14 are not, in fact, mutually exclusive. On the one hand, the authors who support the first do not exclude the role of coarticulation in causing centralisation,[141] while on the other, the authors supporting the second model acknowledge that a very common effect of coarticulation is 'centralisation' (see Flemming, 2005:27). Looking at the two graphs in Fig. 14 it should be quite easy to see why the two models might in many cases predict similar patterns of reduced allophones, at least for the phonemes

[141] See especially Van Bergem, 1993:12: 'In general, both the amount and the direction of the shift of steady-state formant frequencies in reduced vowels seem to be specific of the consonantal frame in which they occur.'

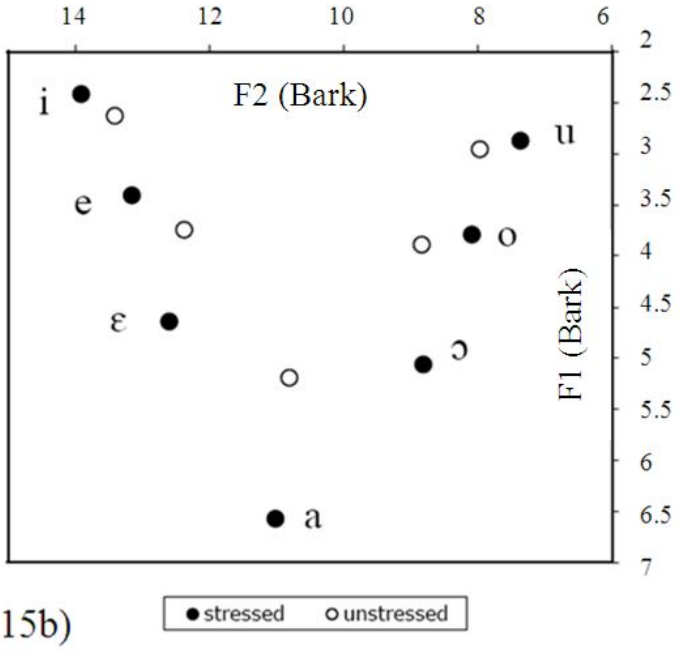
situated in the mid-low part of the vowel space. If, remaining with the Campidanese-type heptaphonemic inventory, the vowels /ɛ, a, ɔ/ are produced at a faster rate,[142] both models would predict for those vowels a higher and more centralised realisation than expected for their canonical or ideal more peripheral counterparts. Another analogy between the two models is that both predict, for reduced vowels, an overall shrinkage of their space of existence.

A first clear difference between the two models can be found with regard to the expected direction of this shrinkage. Consistently with its name, the CBM predicts that all the reduced phonemes would somehow converge towards the centre of the vowel space, whereas the UBM would predict the general elevation of the same vowel space. This difference should be especially apparent for high and high-mid vowels, since they are expected by UBM not to be normally lowered, contrary to what is expected by CBM. Some instrumental studies seem to support Flemming's UBM (Mooshammer & Geng, 2008; Calamai, 2003), whereas others seem to support the CBM (Savy & Cutugno, 1997). It should be pointed out that sometimes the difference between the two models is so subtle that doubts can be raised about the support that experimental data can give to one or the other. In this respect, a couple of examples are given in Fig. 15.

[142] As it will be see below in § 3.2, vowel duration is not the only variable considered in the literature to possibly affect the degree of coarticulation.



15a)



15b)

Figure 15: Two examples of acoustic comparison between stressed and unstressed vowels. Figure 15(a) has been extracted from Van Bergem (1993), and was interpreted by the author as a proof of the schwa-like reduction pattern of unstressed vowels in Dutch;[143] Figure 15(b), extracted from Flemming (2005:19), represents the stressed (filled circles) and unstressed (empty circles) vowel triangle of Standard Italian, and was used by the author to support his UBM.

[143] The mean values displayed in Fig. 15(a) represent, from top to bottom: ISO (syllable spoken in isolation), S-A (stressed syllable in an accented content word), NS-A (unstressed syllable in an accented content word), F-A (function word followed or preceded by an accented content word), S-NA (stressed syllable in an unaccented content word), NS-NA (unstressed syllable in an unaccented content word), F-NA (function word followed or preceded by an unaccented content word). See Van Bergem, 1993:5.

The results presented in Fig. 15(a) were interpreted by Van Bergem (1993) as 'a shift away from the 'ideal' target position into the direction of the schwa' (p. 8). There seems to be no doubt about this interpretation as regards the formant frequency shift (from the 'ideal' target) of open and open-mid vowels, while close vowels only seem to undergo horizontal centralisation and not a vertical shift towards the schwa region. All in all, Van Bergem's results do not appear to be too different from what is expected in Flemming's model, according to which a certain degree of contraction on the F2 axis is predicted for each vowel, along with an overall elevation of the vowel space floor.

On the other hand, the phonologically reduced vowel inventory[144] of standard Italian reported by Flemming in support of his UBM[145] and presented here in Fig. 15(b) shows that [i] and [u], and [e] and [o], are more open in unstressed position on the vertical dimension too, in accordance with the (alternative) centralisation-based model or CBM. This outcome is said by Flemming not to be predicted by his model, but 'could be a consequence of vowel-to-vowel coarticulation with non-high vowels, which would be a natural extension of the present model'.[146] The author does not make clear in what way those results 'would be a natural extension of the present model', since he does not discuss in detail the actual phonetic context causing close and close-mid vowels to lower in the original work by Albano Leoni et al. (1995).

These examples are given here in order to suggest that in some cases it is not easy to interpret experimental data as definitely supporting one or the other vowel reduction model.

3.2 Variables possibly affecting the degree and direction of acoustic vowel reduction

The literature to date has considered several variables that could possibly cause and condition the extent and direction of phonetic vowel reduction. Some of these are discussed below.

a) *Stress*. The lack of stress has traditionally been considered by phonologists to be the main cause of phonological reduction. In the last few decades, however, phoneticians have tried to answer the question of whether phonetic reduction, i.e. a gradual and not

[144] The stressed vowel inventory of standard Italian includes the seven phonemes /i, e, ɛ, a, ɔ, o, u/, which reduce to [i, e, a, o, u] in unstressed position (see Marazzini, 2002).
[145] See Flemming, 2005:19, Fig. 10. The graph is based on data from Albano Leoni et al, 1995.
[146] *Ibid.*, p. 18.

categorical shift from the target articulation, is caused by stress *per se* or instead by some of its typical correlates, such as duration and articulatory effort. This issue was dealt with in 1963 by Lindblom, who quoted examples from the literature in which no clear correlation between stress and shifts in formant frequency could be demonstrated (p. 1774). As a consequence, he specifically considered the stress effect on undershoot primarily attributable to one of its typical correlates, i.e. duration. In other studies the effect of the variable 'stress' on centralisation/undershoot seemed to co-occur with (or even be overcome by) other variables, such as 'word class'. Van Bergem (1993), for example, found that 'monosyllabic function words with primary stress had the same poor quality as unstressed vowels from content words' (p. 20).

b) *Duration*. In general terms, the role of duration in conditioning the more or less canonical realisation of a segment is not under question. However, Lindblom's (1963) proposal that reduction should be caused by timing,[147] thus underestimating the effects of other variables such as articulatory effort or speaking style, has been challenged in various works. Van Son (1993), for example, tested whether coarticulatory effects could only be attributable to mechanical limitations due to an increase in speech rate. He showed that in certain conditions (e.g. in the normal-rate reading of a long written text by a 'very experienced speaker' compared to a 15% faster reading by the same speaker), the variable *duration* did not visibly affect the degree of target undershoot.

c) *Articulatory effort*. Point 'b)' above mentions the relevance that Lindblom (1963) attributes to 'timing' at the expense of the variable 'articulatory effort', i.e. the degree of muscular effort made by the articulators in order to produce, in this particular case, vowels. The role of this factor is, however, acknowledged in Lindblom & Studdert Kennedy (1967) as 'vocal effort', and in Lindblom (1968) as 'force', to better account for the variability in speech. The concept of articulatory effort becomes a fundamental part of Lindblom's 'hyper- and hypospeech theory' (Lindblom 1990), according to which the speaker adapts the oral signal by balancing the 'output-oriented control' (or the need to be understood) and the 'system-oriented control' (or need to save effort) in

[147] In absolute terms, 'duration' and 'timing' are not to be considered as synonyms; in fact, the latter is directly related to speech rate, whereas the former concerns the period of time during which a linguistic event is produced. This said, Lindblom (1963) considers 'timing' and 'duration' as strictly linked: 'Since the speed of articulatory movement is thus limited, the extent to which articulators reach their target positions depends on the relative timing of the excitation signals.' (p. 1778). See also p. 1779: 'As a vowel becomes shorter, there is less and less time for the articulators to complete their "on-" and "off-glide" movements within the CVC syllable.'

a production aimed at reaching 'sufficient contrast' (pp. 404–405). Hence, in some cases the output-oriented control requires undershoot to be somewhat reduced: 'Compensation for rapid timing of the force commands can be achieved by increasing movement velocities which in turn is brought about by increasing force amplitudes' (p. 415).

Hyperarticulation might be also seen as a strategy to enhance the distinctiveness of vowels in stressed position (de Jong, 1995). Other than that, the lack of hyperarticulation in unstressed vowels might itself be considered an articulation-based justification for vowel centralisation in the unstressed domain (see Mooshammer & Geng, 2008:118 for a review of the literature on the topic).

d) *Locus-target distance*. The 'locus-target distance' is defined in Moon & Lindblom (1994:40) as 'the extent of the CV formant transition'. In the same study, the authors attribute the great formant frequency shifts that they found in their data to the large locus-target distance for some of the sequences included in their study, such as the /wVl/ string (p. 51). As a result, the authors conclude that 'locus-target distance and vowel duration play an important role in determining undershoot' (p. 53); on the same page, the variable 'speech style' is also considered to influence vowel undershoot.

e) *Speech style*. In the 'Duration' section of this brief review an example is given of a faster speech rate proving not to affect vowel undershoot (see Van Son, 1993). That example is probably suitable for the purpose of showing that speech *rate* should be differentiated from speech *style*. Two different speakers may, in fact, produce speech with a similar tempo and rhythm, but one may nevertheless be more informal than the other. Needless to say, when the specific effects of speech style are studied, more informal speech productions present higher coarticulatory effects than more formal ones.[148]

f) *Language-dependent factors*. Data from Nord (1975, 1986) indicate that unstressed Swedish vowels exhibit visible coarticulatory effects in word-initial position, whereas they seem to go towards a schwa-like pattern in final position. In this respect, Van Bergem (1991:3) suggests that 'the schwa probably requires the least amount of articulation in many consonantal contexts', implying that: a) this is the main reason

[148] See Savy & Cutugno, 1997 and Meunier & Espesser, 2011.

why phonological reduction normally results in the change of a vowel into schwa;[149] b) schwa-like reduced vowels are expected to occur more frequently as coarticulatory pressure reduces, such as, for example, in word-final position, consistently with Nord's results.

g) *Other factors.* Effects on the degree of undershoot/centralisation are said to be possibly modified as a function of 'word class', i.e. function words vs. content words (van Bergem, 1994) and 'word structure' (Moon and Lindblom, 1994). The role of these variables in affecting vowel reduction can be attributed to several factors. For example, content words are assumed to be less frequent than function words, and may require more articulatory effort to be uttered than the latter. This could justify the results by Van Bergen (1993), reported in section '(a)' above, where 'monosyllabic function words with primary stress had the same poor quality as unstressed vowels from content words'. Also, as regards 'word structure', Moon and Lindblom (1994) found that the degree of undershoot increased above all for the first vowel in such sequences as 'will-willing-Willingham'. This outcome was accounted for by assuming that different word structures might cause the target vowel(s) to show different durations, and hence to exhibit different degrees of undershoot.

The present list is obviously not exhaustive and only contains some of the many variables possibly affecting the degree and direction of vowel reduction. Nonetheless, it constitutes the basis on which the experimental procedure was established in order to gather information on possible formant frequency shifts among Sardinian stressed and unstressed mid vowels.

[149] The author goes even further claiming that the very definition of 'phonological reduction' refers to the change of a vowel into a schwa. This generalisation, which might function well for such languages as English or Dutch, would exclude from the category of 'phonological reduction' the examples and the languages reported here in Fig. 15 since those systems also present non-schwa like reduced vowels. Similar considerations can be made if general reviews of typological reduction are taken into account, such as Flemming, 2005 and Crosswhite, 2004, in which the reduction towards /ə/ is considered to be just one among the many possible reduction patterns. The possibility of a language not presenting phonologically reduced schwa-like vowels is accounted for by Van Bergem (1994:12), taking Italian as an example: 'the sound change 'full vowel -> schwa' can only occur when the schwa is included in the phonological system of a language. If this is not the case (as, for instance, in Italian), the process does not come beyond the stage of acoustic vowel reduction'. This claim seems to be supported by a circular justification since schwa can be lexicalised only if the system already has a lexicalised schwa, leaving unanswered the question of how was it possible for the first schwa to be lexicalised. This problem is even more apparent when the author explains the diachronic diffusion of schwa in Dutch: 'Perhaps the schwa did not even exist at all in the early days of the Dutch language. In modern Dutch almost one out of three vowels is a schwa' (pp. 11-12). It seem clear that there is a contradiction to the claim that 'full vowel -> schwa' can only occur when the schwa is 'included in the phonological system of a language', since Dutch did not have that phoneme 'in its early days'.

3.3 Preliminary data on Sardinian stressed and unstressed vowels, and experimental hypotheses

Among the instrumental studies carried out on Sardinian vowels, some interesting results for stressed and unstressed vowels are reported by Contini (1987:449). These results show mean F1, F2 and F3 values for all seven vowels of three Sardinian dialects (whether all contrastive, as in Campidanese, or including the two close-mid allophones of /ɛ, ɔ/, as in northern Sardinian varieties). The mean F1 and F2 frequency values of each vowel are reported here in Table 5 and also plotted on the vowel space in Fig. 16.

	Northern Logudorese (Nughedu S.N.)				Nuorese (Orani)				Campidanese (Sanluri)			
	stressed		unstressed		stressed		unstressed		stressed		unstressed	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
i	246	2290	296	2284	269	2345	298	2216	290	2182	325	2155
e	331	1893	416	2083	341	1981	436	1980	380	2035	387	1835
ɛ	462	1760	500	1768	502	1775	516	1796	460	1970	460	1830
a	725	1297	658	1425	757	1474	728	1522	615	1455	637	1405
ɔ	495	997	506	1173	493	968	536	1240	535	1042	527	1037
o	344	975	400	1100	339	896	400	1100	437	915	445	885
u	297	925	348	1042	304	820	340	987	332	785	385	790

Table 5: F1xF2 values, in Hertz, for stressed and unstressed vowels of three Sardinian varieties extracted from Contini (1987:449).

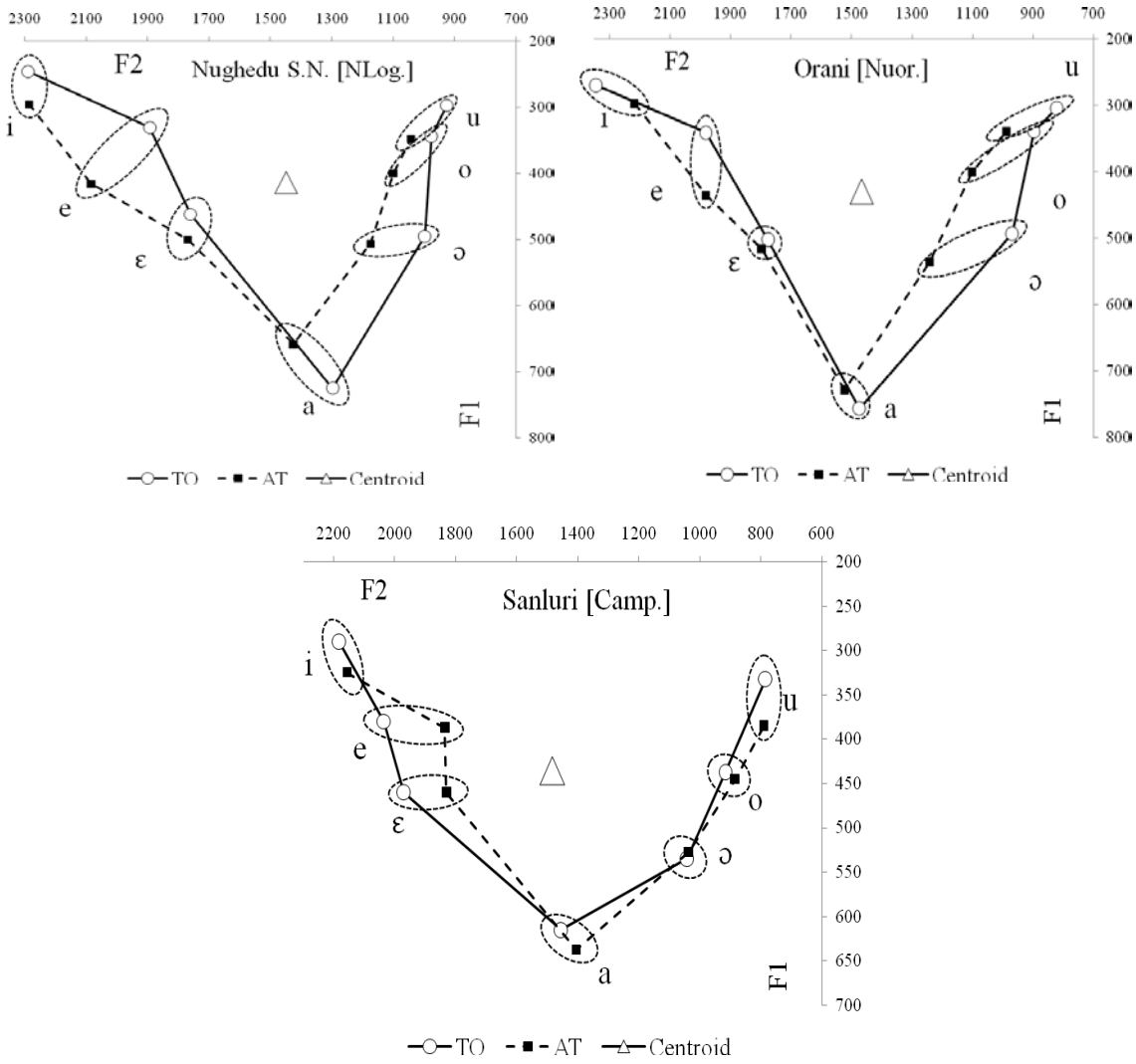


Figure 16: Representation on the vowel space of F1xF2 values, in Hertz, for stressed (TO) and unstressed (AT) vowels in three Sardinian varieties extracted from Contini (1987:449). The dotted ellipses encompass the mean values of each stressed vowel and its unstressed correspondent.

Formant data indicate for unstressed /i/ and /u/ a certain degree of lowering in all the dialects and, for Northern Logudorese /u/ and Nuorese /i, u/, a convergence towards the centre of the vowel space along the horizontal axis. These first data would not challenge CBM, since they can roughly be read as shifts heading somewhat towards the schwa region. Also, it is not impossible to account for Northern Logudorese /i/ and Campidanese /i, u/ with a non-strict version of CBM, in that a certain degree of centralisation is visible on the vertical axis, although not on the horizontal axis. The same data would, on the other hand, be in contrast to UBM, even though, as will be specifically addressed further on in this section, the lack of detailed information on the consonantal context surrounding target vowels in Contini's work

makes it impossible to evaluate whether the place of articulation of some flanking consonants or vowels have played a role in lowering close vowel targets, a possibility which was not excluded by Flemming's UBM (2005:18).

A clear violation of both models would, by contrast, seem to be constituted by the more peripheral position, on the horizontal axis, of unstressed [e][150] in Northern Logudorese, since both models predict a more centralised shift – not a more centrifugal one – of the same unstressed vowel. On the vertical dimension, an inconsistent finding with both UBM and CBM would be the lowering of unstressed /ɛ/ in Northern Logudorese and /ɔ/ in Nuorese, since both models predict a rising of the same vowels in unstressed position. For the same reason, the lack of rising of Northern Logudorese /ɔ/, Nuorese /ɛ/ and Campidanese /ɛ, ɔ/ would also be inconsistent with the two models. Finally, unstressed /a/ in Northern Logudorese and Nuorese seems to follow the centralisation/raising patterns predicted by both models, even if the same vowel in Campidanese exhibits the opposite behaviour.

The results by Contini have been reported here in order to test the predictions of CBM and UBM against preliminary data on Sardinian stressed and unstressed mid vowels. It should not be forgotten, however, that the aim of Contini's study was to gather general acoustic data concerning the whole set of the most typical linguistic sounds of central-northern Sardinian, whereas a specific study on acoustic vowel reduction would require a specifically designed questionnaire aimed at isolating, among others, context-dependent variables, given the undoubted importance of coarticulatory effects on vowel reduction. In this respect, as anticipated in Chapter 2, no information is available in the experimental protocol by Contini (1987) on the consonantal environment surrounding the target vowels, hence the role of coarticulation in phonetic vowel reduction cannot be reliably evaluated for the results shown here in Table 5 and Fig. 16. Contini, moreover, does not give the mean duration values for stressed and unstressed vowels, leaving unexplored the issue of how vowel duration possibly influences reduction. This said, it should be clear so far that finding information on the

[150] It should be remembered here that the brackets are used to indicate close-mid vowels in Northern varieties, since a traditional contrastive-based phonological approach only attributes the status of phonemes to Campidanese /e/ and /o/, whereas the same vowels in Northern Logudorese and Nuorese are to be considered as allophones of /ɛ/ and /ɔ/, respectively.

acoustic reduction of Sardinian mid vowels constitutes the third aim of the present dissertation.[151]

In preparing the questionnaire to gather instrumental data on the Sardinian acoustic reduction for mid vowels, all the variables enlisted in § 3.2 have duly been taken into account in the present work.

The variable *stress* was isolated by comparing the target vowels in stressed and unstressed position. The variable *locus-target distance* was isolated by comparing stressed and unstressed target vowels flanked by consonants agreeing in place of articulation. For example, the word ['sɛtɛ] ('seven'), with the stressed target vowel embedded in a dentoalveolar context, was compared with the prestressed (or AT-1) correspondent in [sɛ'tanta]. The variable *duration* was accounted for by measuring vowel durations and looking for possible correlations between this variable and the degree and/or the direction of formant frequency displacement from the expected realisations. Also, all efforts were made to isolate where possible the variables *speech style* and *articulatory effort* by ensuring that all the informants produced the corpus using a similar speech style (they were asked to read and translate at a comfortable rate short declarative phrases from Italian into Sardinian) and in similar environmental conditions (they were recorded in quiet offices with low ambient noise and with the interviewer at a normal conversational distance).

In evaluating our data, the most challenging variable to be accounted for proved to be the *language-dependent factor*, which required a partially different analysis procedure with respect to that followed by the studies referred to here. Additionally, a language-specific theoretical framework will be proposed in order to better explain the results of the experimental investigation (see § 6.4.3 below).

To sum up, the present chapter covers the vowel reduction process – specifically, acoustic and phonetic (non-categorical) vowel reduction. It has been seen that some preliminary results found in the literature on Sardinian unstressed mid vowels might challenge the predictions of both the undershoot-based model (UBM) and the centralisation-based model (CBM). This chapter also attempted to define a suitable method of data acquisition and interpretation of the

[151] A summary of the three main aims of the present work is provided in § 4.4.

process of acoustic reduction of Sardinian unstressed vowels. As anticipated a few lines above, it is believed here that language-dependent (i.e. phonological) factors may play a not irrelevant role in conditioning the degree and the direction of vowel reduction in Sardinian. A more in-depth examination of all these aspects concerning vowel undershoot and the centralisation of Sardinian unstressed mid-vowels constitutes the third aim of the present dissertation.

Chapter 4

Previous instrumental research on Sardinian and Catalan vowels and summary of the aims of the present work

The present chapter contains a brief list of acoustic-instrumental studies available in the literature on Sardinian (sections 4.1 and 4.3) and Catalan (sections 4.2 and 4.3). Section 4.4 summarises the aims of the present study.

4.1 Sardinian

In *Gli studi di linguistica sarda*, Paulis[152] offers a rich overview of studies on Sardinian carried out between the nineteenth century and 1982. Even bearing in mind that this review of the literature may not be exhaustive, the almost total absence of instrumental studies is nonetheless striking. There are, however, some noticeable exceptions, such as the pioneering work *Sur un ancien substrat commun à la Sicile, la Corse et la Sardaigne* by Millardet, published in 1933, and the 1972 study by Contini & Boë, in which the two authors analyse the spectral differences between oral and nasal vowels in the Campidanese-speaking town of Sanluri. Another interesting instrumental work on Campidanese vowels (not included in Paulis's review) was carried out by Schirru in 1976.

In the last few decades, different instrumental works have been carried out on Sardinian, particularly in the field of prosody.[153] As regards segmental phonetics, the most important instrumental study is undoubtedly the *Étude*[154] by Contini (1987), carried out across 214 towns and cities of central and northern Sardinia. That work included a series of dialect maps containing the isoglosses of the principal linguistic sounds and covering all the northern Sardinian varieties and some of the southern Sardinian varieties (see Contini, 1987b). As anticipated above in Chapter 1, the linguistic tables by Contini are used here as the main framework of reference in order to set specific virtual boundaries between some of the major Sardinian varieties.

[152] See Paulis, 1982.
[153] See Vanrell et al., 2013 § 1.2 for a list of the most important works on the subject.
[154] *Étude de géographie phonétique et de phonétique instrumentale du sarde*.

Another interesting instrumental study on Sardinian vowels, presented in 1997 by Cossu,[155] tested the possibility that the Campidanese variety of San Sperate could present a slightly different vowel reduction process with respect to the majority of other Campidanese varieties; her findings are schematically reported in the present study in Fig. 13. It is also worth mentioning the PhD thesis by Frigeni (2009), in which instrumental data on the different quality between nasalised and non-nasalised vowels in Nuorese and Campidanese are reported.

In recent years, several experimental studies on Sardinian and other minority languages of Sardinia have been carried out in the form of *Tesi di Laurea* at the Faculty of Foreign Languages of the University of Sassari. They have dealt with the role played by the underlying Sardinian phonetic and phonological system in the correct perception and production of foreign linguistic sounds by Sardinian speakers.[156]

4.2 Catalan

In 1933, the year in which Millardet published the first instrumental study on Sardinian, Pere Barnils, the first director of the Laboratori de Fonètica of the Institut d'Estudis Catalans (IEC), died in Barcelona. Barnils left behind a large number of studies in instrumental phonetics (among other fields), concerning the description of the vowels and consonants of different Catalan varieties (an overview of his works is presented in Julià i Muné, 2000). The Spanish Civil War (1936–1939), and the Francoist dictatorship that followed, resulted in a long period of inactivity for instrumental (and other) studies on Catalan, which lasted until the early 1980s.[157] Among the most recent works, some have dealt extensively with the formantic description of Catalan vowels, such as the PhD dissertation by Herrick (2003) on the acoustic features of stressed and unstressed vowels in six Catalan varieties, Carrera & Fernández (2005), which is devoted to the analysis of mid vowels in different varieties, and Recasens & Espinosa (2006 and 2009), which provide a detailed description of the acoustic properties, dispersion and variability of stressed vowels in eight Catalan varieties.

As regards instrumental research work on Algherese, it still seems to play a quantitatively marginal role compared to traditional impressionistic studies, with a probable exception in the

[155] See Cossu, 1997/2009.
[156] See, among others, Bissiri, 2006 and Puddu, 2007.
[157] For works on Catalan vowels published in the 1980s, see Recasens 1984, 1985 and 1987.

field of prosody.[158] The first spectroacoustic analysis of Algherese vowels was probably carried out by Ballone (2008), followed by three other instrumental works by the same author concerning the possible pressure of Sardinian metaphony on Algherese and on the Italian spoken in Alghero,[159] the presence and the quality of epenthetic [i] in some consonantal clusters,[160] and the acoustic analysis of an interview carried out by a local television in 1983 on a 100-year-old informant.[161] The first two studies were presented as *Tesi di Laurea* at the University of Sassari.[162]

4.3 Further remarks on the previous research

The list of studies in the previous section includes different works on vowel characterisation in Sardinian (e.g. Contini, 1987), Algherese (e.g. Ballone, 2008) and other Catalan varieties (e.g. Recasens & Espinosa, 2006). At first sight, the fulfilling of the aims of the present dissertation could have been achieved (at least partially) by simply comparing the acoustic data among these (and possibly other) instrumental works on the subject. For various reasons, however, this was not possible. It is known, in fact, that the methodology for each study is normally designed to fulfil specific aims, and there is no guarantee that the data can also be successfully used to meet other aims. For example, the study by Contini (1987) was aimed at gathering impressionistic and instrumental information on the linguistic sounds from central and northern Sardinia. The instrumental data were gathered by means of '*palatographie systématique* […] *labiocinématographie et de films radiologiques*' in ten towns, and corresponded to some characteristic realisations '*peu connues dans le domain roman*' (p. 38). With respect to vowels, the acoustic analysis was performed on the first three formants of stressed and unstressed vowels of 15 varieties (p. 448). What is most striking in Contini's work is the size of the overall corpus gathered to carry out the acoustic and impressionistic analysis. He covered 214 towns all over the central and northern regions of Sardinia, and each questionnaire included 200 words: these two first figures alone indicate that the overall analysed segments (either instrumentally or on a perceptual-impressionistic basis) may have exceeded 40,000 tokens. This calculation is probably an underestimation, since in many towns more than one informant was interviewed, and the overall number of speakers was

[158] See, among others, Contini, 1995; Vanrell et al., 2011 and 2013b; Prieto et al., 2009; Cabré et al., 2011 and 2013.
[159] See Ballone, 2010.
[160] See Ballone, 2010b.
[161] See Ballone, 2008b.
[162] Another *Tesi di laurea* concerning the acoustic quality of Algherese vowels is Colella, 2010.

almost twice as high (382) as the number of places of investigation (214); this suggests that the amount of tokens analysed may be much greater, not to mention the fact that some words probably contained more that just one target segment.

Such an extensive investigation probably allowed the author to fulfil the main aim of his investigation, i.e. to provide a general acoustic description of the linguistic sounds of Logudorese. On the other hand, the questionnaires were not specifically designed to isolate contextual factors, hence some problems could emerge when using the same data to test the two predictions of the Adaptive Dispersion Theory discussed above in Chapter 2, since, as shown in the same chapter, vowel system expansion and vowel variability may *also* depend on contextual factors.

Another example of the possible problems in comparing data among studies designed for different purposes may be found in Ballone (2008). In that study, the seven vowel phonemes of Algherese were measured in minimal pairs: [v**i**l], [v**e**l], [v**ɛ**l], [v**a**l], [v**ɔ**l], [v**u**l] (‘coward’, ‘old’, ‘veil/film’, ‘valley’, ‘flight’, ‘I want’). The missing vowel /o/ was also compared with its open-mid correspondent /ɔ/ in the minimal pair [ˈb**ɔ**ta] (‘boot’) – [ˈb**o**ta] (‘barrel’). This strategy allowed the researcher to isolate the variable ‘context’ in the spectral analysis of the target vowels, but no information could be gathered on the coarticulatory effects that different consonant contexts may exert on the target vowel, such as is required in the present work.

As regards the study by Recasens & Espinosa (2006) on the vowel phonemes of the four major Catalan varieties, this met almost all the requirements to fulfil the aims of the present study, in that the questionnaire included the whole set of Catalan stressed vowels flanked by consonants agreeing in place of articulation so as to better isolate and identify the effects of a given context on the target vowel. Hence, the experimental protocol in question appears to be a suitable framework of reference with which to design a method for the present study and, in so doing, to obtain reliably comparable data between Sardinian, Algherese and the major Catalan varieties.

4.4 Research goals

Chapter 1 introduced the first aim of the present dissertation, i.e. the evaluation of the possibility that immigrants to Alghero have changed, over the centuries, the Catalan origin quality of Algherese vowels. This aim will be achieved through an acoustic comparison between the stressed vowels of Algherese and the corresponding vowels in other Catalan varieties and Sardinian, the latter language normally being described by scholars as the language that has affected Algherese most significantly. More specifically, the Sardinian variety which is usually said to have played a key role in modifying Algherese is Northern Logudorese, both because this was (and still is) the language variety mostly spoken in the territories surrounding the city, and also because this was the L1 of the majority of Sardinian newcomers. Hence, if acoustic differences are found between Algherese vowels and their correspondents in other Catalan varieties, this fact is expected to be due to the influence of Sardinian, in particular its Northern Logudorese variety.

In shaping our research hypothesis on a possible Sardinian influence on Algherese vowels, an effort has been made to understand the possible interaction of the variables considered in the literature in such a way as to facilitate or make harder for a newcomer the achievement of a native-like pronunciation in L2. For example, two factors normally said to cause a learner to maintain some degree of 'foreign' accent are a post-pubescent age of arrival in an L2-speaking area and the frequent use of the learner's own L1, as was probably the case for many Sardinian newcomers. If this and other factors may have increased the possibility that Algherese vowels have changed acoustically in a Sardinian-like way over the centuries, other factors have been seen to perhaps work instead in favour of the conservation[163] of the original vowel qualities, such as the (presumed) complete mastery of Algherese by the sons and daughters of immigrants born in the city. Following this theoretical analysis, it appeared that over the course of the centuries the innovative factors may have overcome the conservative ones. The results concerning the first aim of the present study will be presented and discussed in § 6.2.

[163] It would probably be more correct to say the *relative* conservation, since linguistic change might depend on many other factors than immigration (see Labov, 1994).

The second aim of the present research was introduced in Chapter 2 and concerns the testing of two predictions of the Adaptive Dispersion Theory against instrumental data regarding Algherese, Sardinian and other Catalan varieties.

The first ADT prediction claims that a positive relationship should hold between vowel inventory size and vowel space dispersion, in that the vowels of a given dialect/language with more vowel phonemes should be more expanded than the corresponding vowels in a dialect/language with fewer vowel phonemes. This difference in degree of dispersion is due, according to ADT, to the need to reduce the risk of confusion in richer inventories by making phonemes more dissimilar. In this respect, the inclusion in this study of Algherese and Sardinian varieties, which possess a different number of contrastive vowels, constitutes a good basis on which to test this first prediction. Some instrumental data provided by Contini (1987) suggested that this positive relation does not hold across Campidanese, Nuorese and Northern Logudorese, since the first of these varieties, which possesses seven contrastive vowels, presented a smaller area for point vowels than the other two varieties, which are pentaphonemic.

The second prediction of ADT claims that the degree of vowel variability should be inversely proportional to the vowel inventory size, i.e. vowels are expected to be more variable in smaller than in larger inventories. As already seen above for the first prediction, the corpus of the present work was gathered among dialects and languages differing in the number of contrastive vowels, which is also a suitable condition for testing this second ADT prediction.

Sardinian varieties have, however, also proved to possess some 'borderline' characteristics of both pentaphonemic and heptaphonemic inventories. On the one hand, the more crowded Campidanese inventory is normally said to be so as a function of a reduced number of minimal pairs, generated by the combination of metaphony and vowel reduction in the same variety. In this respect, a more etymologically-based approach (see Bolognesi, 1998/2012 and Frigeni, 2002) would suggest that the Campidanese phonological inventory actually equals that of Logudorese in that each of the two systems would possess five vowel phonemes. Following this approach, the four Sardinian pentaphonemic varieties are expected to be less dispersed and more variable than their counterparts in the more crowded Catalan inventories.

On the other hand, all Sardinian varieties exhibit an allophonic distribution of vowels quite similar to that of such heptaphonemic systems as Algherese and other Catalan varieties. In this respect, the possibility will be examined of considering Logudorese and Campidanese varieties as possessing a seven-vowel inventory, where 'seven-vowel inventory' is to be intended here as a blanket term indicating both contrastive and non-contrastive vowels. In this respect, Sardinian vowels are expected to be as dispersed and variable as their counterparts in Algherese and other Catalan dialects, with the exception of the more crowded Majorcan variety, which should instead exhibit the most dispersed and least variable vowels. Data concerning the relation between inventory size and degree of vowel dispersion and variability will be presented and discussed § 6.3.

The third aim of this research work concerns the analysis of the acoustic reduction of Sardinian unstressed mid vowels, and was introduced in Chapter 3. The starting point of this research topic is constituted by the data presented in Contini (1987) on Sardinian stressed and unstressed vowels. In fact, those results suggested that the formant frequency shift exhibited by unstressed vowels was quite eccentric with respect to the predictions made by the centralisation-based model (CBM) and Flemming's undershoot-based model (UBM). In none of the dialects studied by Contini did the unstressed open-mid vowels present a vertical shift towards the centre of the vowel space, as predicted instead by both CBM and UBM. Moreover, Northern Logudorese /ɛ/ and /ɔ/, and Nuorese /ɔ/ showed formant frequency shifts heading towards more open areas rather than towards more centralised areas. In the case of [e] and [o], in Northern Logudorese these vowels were seen to follow neither a closing (UBM) nor a centralising (CBM) formant shift, as much as they seemed to invade the space of existence of /ɛ/ and /ɔ/.

Some exploratory measurements already carried out in the present work have indicated that, as the data by Contini suggest, it is possible that the acoustic reduction of Sardinian unstressed vowels presents elements not predicted by UBM and CBM, and also that language-dependent variables need to be taken into account for the interpretation of the results. The data concerning Sardinian unstressed mid vowels will be presented and discussed in § 6.4.

Chapter 5

Method

Chapter five explains the method used to select the participants (section 5.1) and the points of survey (section 5.2), to compile and adapt the different questionnaires (section 5.3 and following), and to record (section 5.4) and analyse the data (sections 5.5 and 5.6).

5.1 Participants

Five native male speakers were interviewed for each chosen dialect: five for Algherese (henceforth Algh.) and 20 for the Sardinian (henceforth: Sard.) varieties, i.e. Common Logudorese, Campidanese, Nuorese and Northern Logudorese (henceforth: CLog., Camp., Nuor. and NLog., respectively). The indispensable requirement for each informant to be selected was his native competence in the required variety. The interviewer only used Algh. in his interaction with Algh. informants, and the CLog. variety of Sard. to interact with the other informants. Special attention was devoted to understanding whether each informant normally and fluently used his own variety to interact with people other than the interviewer, i.e. friends and/or relatives, during the phases preceding and following the recording. Only in one case (speaker_04 from Sinnai) did the informant shift every now and then from Sardinian to Italian and vice versa when talking to other native-speaking friends, whereas for all the other participants similar interactions were found to always and fluently take place in local idioms.

The other two requirements accounted for in the choice of the informants were *gender* (only male speakers were interviewed) and *education*, in the sense that informants with university degrees were avoided. In absolute terms the condition of being a university graduate does not necessarily imply a lower linguistic competence in one's own mother tongue; in the specific case of Sardinia, however, it should be pointed out that the two available universities are located in cities, Cagliari and Sassari, where Italian is by far the most-used language, and in many cases university students live for some years in those cities with a continuous exposure to Italian in everyday activities and classes.

The age of the participants ranged between 40 and 65 years and every effort was made to include a balanced age variation within each dialect, as reported in Table 6.

		informant	main job	pl. of birth	age	education[164]
Alghero [Algh.]	01	PS	farmer	Alghero	50	lic. media
	02	SM	musician	Alghero	39	dipl. superiore
	03	PB	health educator	Alghero	57	lic. media
	04	SS	workman	Alghero	45	dipl. superiore
	05	AC	workman	Alghero	41	lic. media
Pozzomaggiore [CLog.]	01	MM	salesperson	Pozzomaggiore	53	dipl. superiore
	02	FF	surveyor	Sassari	51	dipl. superiore
	03	TC	builder	Pozzomaggiore	54	lic. media
	04	BC	workman	Sassari	61	lic. media
	05	SP	workman	Pozzomaggiore	45	lic. media
Sinnai [Camp.]	01	NC	workman	Sinnai	59	dipl. superiore
	02	LA	workman	Sinnai	53	dipl. superiore
	03	BM	workman	Sinnai	55	lic. media
	04	AP	petty officer	Cagliari	42	dipl. superiore
	05	MM	employee	Cagliari	46	dipl. superiore
Fonni [Nuor.]	01	BP	driver	Fonni	41	dipl. superiore
	02	FD	naval officer	Fonni	47	lic. media
	03	GBS	shepherd	Fonni	48	lic. media
	04	BS	consultant	Fonni	58	lic. media
	05	FL	shepherd	Fonni	64	lic. elementare
Ittiri [NLog.]	01	GBD	farmer	Ittiri	48	lic. media
	02	SM	workman	Ittiri	51	lic. media
	03	TC	employee	Ittiri	53	lic. media
	04	GBS	manager	Ittiri	49	dipl. superiore
	05	GC	workman	Sorso	65	lic. media

Table 6: Summary of the main sociolinguistic characteristics of the 25 informants recorded for the present study.

5.2 Points of survey

The city of Alghero was obviously the natural candidate for the collection of Algh. data, in that this Catalan (henceforth: Cat.) variety is only spoken in that city if emigrants are not taken into account.

[164] Under the Italian education system, students normally achieve the 'lic. media' (i.e. the 'diploma di scuola media inferiore') at 13–14, and the 'dipl. superiore' (i.e. the 'diploma di scuola media superiore') at 18–19.

As regards the other points of survey, towns were chosen in accordance with the possession of three minimum requirements. The first was the localisation of each town in the areas where the four chosen varieties (i.e. CLog., Camp., Nuor. and NLog.) are spoken.

The second criterion was more strictly linked to the higher probability of finding, in a given dialect, words presenting the contextual characteristics required in the present study. To give one example, the CLog. variety spoken in the town of Nule exhibits many examples of dentalisation of consonants which are palatal in other varieties, thus reducing the possibility for the researcher to find words in which the target vowel is embedded in a palatal context.[165] This difficulty in finding all the required contexts in some specific Sard. varieties had the effect of slightly narrowing down the number of possible candidate towns.

The third criterion was a sociolinguistic one. It was decided to avoid cities with more than 20,000 inhabitants, in accordance with data from the survey *Le Lingue dei Sardi* (see Oppo et al. 2007) suggesting that this figure is an important demographic threshold over which the usage of local languages substantially diminishes, particularly as regards the code chosen to interact with young people and among young people.

Other minor factors were also taken into account in the choice of the points of survey. These should be seen as functional tools to aid the fulfilment of the criteria described above, e.g. the possibility for the researcher to gather linguistic information about candidate towns both from descriptive works and from digital archives of speech recordings, and also the possibility of the interviewer having direct contacts in his hometown (Alghero) with people from other candidate towns in order to facilitate the conducting of the necessary exploratory interviews.

In sum, in addition to the city of Alghero, and in the light of the criteria set out in the present section, the final choice fell on the towns of Pozzomaggiore [CLog.], Sinnai [Camp.], Fonni [Nuor.] and Ittiri [NLog.]. With regard to Pozzomaggiore and Ittiri, a further element which conditioned the final choice by the researcher was his almost native competence in the Sardinian varieties spoken there, due to family connections.

[165] Let us consider, among others, the Sard. equivalent of the English word 'Thursday', pronounced with no palatal consonants in Nulese [ˈʤɔʤːa] and with the target vowel embedded in a palatal context instead in other Log. dialects such as Pozzomaggiorese [ˈʤ**o**ʤːa]**.** It should be stated that the difference in quality among the stressed vowels of the two words is a probable consequence of differences in consonantal environment, i.e. it is possible that the second palatal consonant of Pozzomaggiorese has preserved the active metaphonic pressure of the etymological high front contextual vowel [i] (<IOVIA).

5.3 Questionnaires

The data were obtained by asking participants to read a questionnaire containing short declarative sentences with the target word inserted in phrase-final position.

The parameters used in the preparation of the questionnaire were consistent, although with some indispensable adjustments, with those proposed in Recasens & Espinosa (2006) (henceforth R&E 2006). In that study, the seven stressed Cat. vowels[166] were preceded and followed by consonants agreeing in place of articulation, i.e. the labials and labiodentals (henceforth lab.) /p, b, f/, the dentoalveolars (henceforth dent.) /t, d, s, z/, the palatals (henceforth pal.) /ʧ, ʤ, ʃ, ʒ, ʎ, j/, the trill /r/, the dark or velarised /l/, and the labiovelar /w/.[167] In the same study, the possibility was considered, in cases where – due to lexical restrictions – a perfectly symmetrical CVC sequence was not possible, of including consonants of replacement produced in the next closest place of articulation; for example, in the case of the required pal. environment in 'ell recull **e**stris' [rəkuˈʎɛstɾis] ('he picks up the tools'),[168] the substitute for the missing pal. consonant following stressed /ɛ/ was the dentoalveolar /s/.

As mentioned above, the adaptation of the original Cat. questionnaire into Algh. and the Sard. varieties required some adjustments.

The first adjustment concerned the suitability of the contextual consonant /l/ for the purpose of comparisons among the major Cat. varieties (henceforth mCat.), in which this lateral consonant is said to usually be velarised,[169] and, on the other hand, between Algh. and the Sard. varieties, where the same consonant is said not to be velarised.[170]

As shown by Recasens (2012), dialects and languages traditionally assigned a clear or a dark variant of /l/ may present important mean differences in terms of F2 of the same consonant, due to the different degrees in postdorsum retraction and other articulatory characteristics.[171]

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[166] With the addition of the eigth vowel phoneme for Majorcan, i.e. the stressed [ə].
[167] See R&E, 2006:650. This study also includes the velars /k, g/.
[168] *Ibid*.
[169] With the exception of Valencian Catalan, in which this consonant is considered to be 'less dark' (see R&E 2006:649).
[170] See Recasens, 1996:307 with regard to Algh., and Contini, 1987 II - 6.2.1. for Sard.
[171] See Recasens, 2011: 372–374. In Recasens' study, cross-language F2 values were calculated for languages traditionally assigned a clear or a dark variety of /l/. As a result, mean values for clear /l/ in the intervocalic sequence /ala/ amounted to 1221.9 Hz, compared to 972.11 Hz for dark /l/ (mean F2 difference = 249.79 Hz). With regard to the sequence /ili/, the F2 difference was even greater (611.1 Hz), with mean F2 values of 1714.83 Hz for clear /l/ and 1103.73 Hz for dark /l/. These results also indicate that the clear and velarised allophones of /l/ should not be considered in categorical terms, since they present gradual differences across dialects/languages.

As a consequence, a comparison between the /lVl/ series from Algh. and the Sard. dialects with those from mCat. varieties would not fit perfectly into the method chosen in the present study, namely the comparison of a series of vowels embedded in consonantal contexts sharing the same articulatory characteristics. Hence, it has been decided not to include the /l/ context (and consequently the /r/ context, since it was part of the same series) in the questionnaires for Algh. and the Sard. dialects.

Leaving out the context /l, r/ in the present study could, however, raise a methodological problem: how reliable is a comparison between results obtained through mean values of three consonantal contexts for Algh. and Sard. and four consonantal contexts for mCat.? An answer can be obtained if the mean contextual values for mCat. vowels extracted from R&E (2006) are taken into consideration. As shown there in Fig. 7 bottom (reported here as Fig. 17), the major vowel differences as a function of the consonantal context are visible on the F2 axis, and especially for back vowels and /a/. Assuming that formant values can be associated to articulatory events (see below § 5.5.2), the data shown in Fig. 17 would suggest that the consonantal context causing the least acoustic effects on back vowels and /a/ is lab., and the one rendering the same vowels more fronted is pal. Meanwhile, the two consonantal contexts which show an intermediate impact on F2 are dent. and /l, r/. From our perspective, this means that excluding the /l, r/ context will not have an important effect on the final mean cross-contextual formant frequency values for Algh. and Sard. vowels, and therefore that a reliable comparison with Cat. values is still possible.

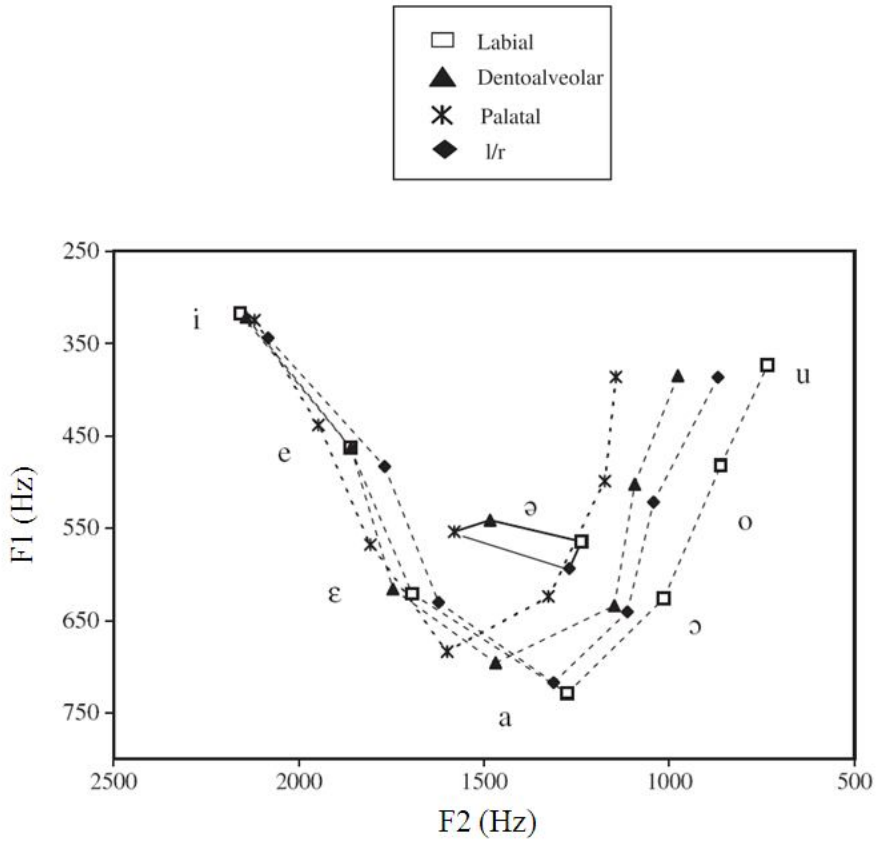


Figure 17: Context-dependent F1xF2 frequency values for the mCat. vowels (extracted from R&E 2006). According to the graph, the lack of /l, r/ context should have a minor impact on the mean formant frequency values across consonantal contexts.

To sum up, it was decided to reduce the number of contextual consonants to three: labials and labiodentals (i.e. 'lab.') which involve lip closure or the formation of a labiodental constriction at the upper incisors, and no active lingual activity; dentoalveolars (i.e. 'dent.') which are articulated with an apical or laminal closure or constriction at the teeth or at the alveolar zone, and involve some tongue dorsum; palatals (i.e. 'pal.') which are produced with a prominent raising of the tongue dorsum towards the hard palate. The set of linguistic sounds expected to perfectly produce the three chosen contexts are:

- *labials* and *labiodentals*: [p, b, β, f, v]
- *dentoalveolars*: [t, d, s, z]
- *palatals*: [ʧ, ʤ, j]

In cases where, due to lexical restrictions, it was not possible to find any words in which the target vowel had both the preceding and the following consonant perfectly agreeing in place of articulation and other articulatory characteristics, the empty slot was filled by one of the following phones:

- (to fill an empty slot of) *labials* and *labiodentals*: [u, z, s]
- *dentoalveolars*: [d̪, θ, i]
- *palatals*: [s, z, t, d, d̪, d̪]

As a result, both the Algh. and Sard. questionnaires included 21 phrases containing each of the seven stressed vowels /i/, /e/, /ɛ/, /a/, /ɔ/, /o/ and /u/ embedded in the three consonantal contexts mentioned above.

A second difference in the acquisition of data between R&E (2006) and the present study concerned the way informants were required to read the questionnaire. The problem lies in the fact that many genuine speakers of Algh. (to mention only the first variety the questionnaire was adapted to) are not as confident with the written model of their language as other Cat. speakers, due to the lack of normal presence of this minor (demographically speaking) Cat. dialect in the education system. As a result, and given the fact that all Algh. speakers are also perfect Algherese-Italian bilinguals, informants were asked to read a set of phrases written in Italian and, as soon as they felt sufficiently confident, to translate them into Algh. The process of translation was actually carried out with no effort at all and in a quasi-simultaneous manner by all informants. The same procedure was also followed in the preparation of the questionnaires and the acquisition of the oral corpus for the Sard. varieties.

With specific regard to Sard., an extra set of phrases was added in order to fulfil the aim described in Chapter 3, i.e. the investigation of acoustic reduction for Sard. unstressed mid-vowels. The Sard. candidate words containing unstressed mid vowels were chosen on the basis of the same parameters used for stressed vowels, i.e. they had to be flanked by consonants agreeing in terms of place of articulation. For example, the unstressed (henceforth AT) [ɛ] of [sɛˈtanta] ‘seventy’, embedded in a dent. context, constituted an eligible term of comparison with its stressed (henceforth TO) cognate in [ˈsɛtɛ] ‘seven’. In order to verify the availability in the four Sard. dialects of words containing the four mid vowels [e], [ɛ], [o] and [ɔ] in the pretonic (henceforth AT-1) and pre-pretonic (henceforth AT-2) position, embedded

in each of the three consonantal contexts (i.e. lab., dent. and pal.), the digital version of the *Dizionario universale della lingua di Sardegna* (henceforth DULS) was consulted[172] in accordance with the following procedure.

In the first place, an automatic search was made by using each possible combination of graphemes referring to the required phonetic clusters. For example, with regard to [e] or [ɛ] surrounded by dent. consonants, every possible sequence of '[…]tet[…]', '[…]ded[…]', '[…]ses[…]', '[…]ted[…]', '[…]tes[…]' and so on was searched.[173]

Given the fact that the DULS contains words from all the Sard. varieties, a second step was needed to verify if the candidate word belonged to all the four chosen varieties or just to one (or some) of them. This second verification was done on another digitalised version of the same dictionary containing the lexical Sard. patrimony divided as a function of the main Sard. dialects.[174]

The third step was the inclusion of each possible candidate word in the exploratory questionnaire, to check whether or not a specific word really belonged to a specific candidate town; in other words, the fact that a word is included in – say – the Log. section of the dictionary does not necessarily mean that the same word is actually used in all the Log. speaking towns.

As a result, 12 extra phrases containing unstressed target vowels were added to the 21 phrases including stressed target vowels. The vowels contained in the extra list were:

- [ɛ], [ɔ], [e], [o] in the lab. context and AT-1 position
- [ɛ], [ɔ], [e], [o] in the dent. context and AT-1 position
- [e], [o] in the lab. context and AT-2 position
- [e], [o] in the dent. context and AT-2 position

[172] Available at http://www.sardegnacultura.it/documenti/7_81_20080107092727.pdf . See Rubattu, 2002.
[173] The search actually also took into account the vowel immediately following the target one, so as to establish whether a specific mid vowel would be open-mid or close-mid according to the metaphony process described above in § 2.3.
[174] Available online at http://www.toninorubattu.it/ita/DULS-SARDO-ITALIANO.htm . It was not possible to search directly for CVC clusters in this latter more dialect-oriented version of the DULS, since this version does not list words in a single list but instead divides lexemes into 96 different sections. At the same time, each of these 96 sections has to to be opened separately, so carrying out a survey of the required CVC sequences in this version of DULS would have required much more time than a survey using the 'inter-Sardinian' version.

The extra list of phrases did not contain any vowels in the pal. context, since the candidate words were not sufficient to fill the slots of a required entire set such as those shown above. The total number of phrases for each Sardinian variety, including stressed and unstressed target vowels, was 33.

5.3.1 Adaptation of the questionnaire to Algherese Catalan

The first adaptation of the original questionnaire by R&E (2006), Table 1, was carried out for Algh., and in the majority of cases perfectly symmetrical consonantal contexts were found in terms of place of articulation. Consistently with the criteria described in the previous section, any time a perfectly symmetrical context could not be found owing to lexical restrictions, substitute candidates were sought among consonants (and, in the cases of /u, i/, vowels) produced in the next closest place of articulation. The complete list of original Italian phrases, and of the expected translation and productions is reported in Table 7.

			original Italian phrase	expected Algh. translation	expected pronunciation	English translation
labial	1	/i/	Accende la pipa	Encén la p**i**pa	[ˈp**i**pa]	‘He lights the pipe’
	2	/e/	Di questo non ne faceva	D’això no ne f**e**va	[ˈf**e**va]	‘He would not do that’ (past tense)
	3	/ɛ/	Gli fa male il piede	Li dol lo p**ɛ**u	[ˈp**ɛ**u]	‘His/her foot aches’
	4	/a/	Gli cade la bava	Li cau la b**a**va	[ˈb**a**va]	‘He is drooling’
	5	/ɔ/	Viene dal popolo	Ve del p**ɔ**pul	[ˈp**ɔ**pul]	‘He is a man of the people’
	6	/o/	La prua e la poppa	La prua i la p**o**pa	[ˈp**o**pa]	‘The bow and the stern’
	7	/u/	Il vento non soffia	Lo vent no b**u**fa	[ˈb**u**fːa]	‘The wind is not blowing’
dentoalveolar	8	/i/	Le fa male la tetta	Li dol la t**i**ta	[ˈt**i**ta]	‘Her breast aches’
	9	/e/	Non ti ho sentito	No t’he ent**è**s	[enˈt**e**s]	‘I didn’t hear you’
	10	/ɛ/	Di anni ne ha sette	De anys ne té s**ɛ**t	[ˈs**ɛ**t]	‘He/she is seven years old’
	11	/a/	Porta il bicchiere	Porta la t**a**ssa	[ˈt**a**sːa]	‘Bring the glass’
	12	/ɔ/	Ha preso un calamaro	Ha pres un t**ɔ**tano	[ˈt**ɔ**tanu]	‘He/she caught a squid’
	13	/o/	Il piano di sotto	Lo pla de s**o**ta	[ˈs**o**ta]	‘The downstairs floor’
	14	/u/	Una buona virtù	Una bona virt**u**t	[virˈt**u**t]	‘A good virtue’
palatal	15	/i/	Ora io leggo	Ara jo ll**i**g	[ʎ**i**ʧ]	‘I am reading now’
	16	/e/	Una cosa veloce	Una cosa ll**e**stra	[ˈʎ**e**stra]	‘(It is) something fast’
	17	/ɛ/	È mezzo etto	És mig h**e**cto	[miˈʧ**ɛ**tɔ]	‘It is half a hectogram’
	18	/a/	C’è troppa chiacchiera	Hi ha massa x**à**txara	[ˈʧ**a**ʧara]	‘There is too much gossiping’
	19	/ɔ/	Io non mangio ossa	Jo no menj **o**ssos	[menˈʧ**ɔ**sːus]	‘I do not eat bones’
	20	/o/	Ho fatto una doccia	M’he fet una d**o**txa	[ˈd**o**ʧa]	‘I had a shower’
	21	/u/	Fai che entri il giudice	Fes que entri el j**u**tge	[ˈʤ**u**ʤa]	‘Let the judge in’

Table 7: Questionnaire of Italian phrases to be read by the Algh. informants and translated into Algh. The table also includes the expected Algh. translation, the expected pronunciation of the target words and the English translation of each phrase.

5.3.2 Adaptation of the questionnaire to Sardinian varieties

- Adaptation to Common Logudorese (Pozzomaggiore)

Pozzomaggiorese was the first Sard. variety to which the Algh. questionnaire was adapted. Some words, such as 'p**i**pa', 't**i**ta' and 's**e**te', already used for Algh., perfectly fulfilled the needed phonetic requirements in this Sard. variety too, and consequently did not require any change at all. By contrast, other words exhibited a rather different outcome in CLog., lacking the required phonetic contexts, and had to be changed.

During the adaptation/preparation of this first Sard. questionnaire, an effort was made to include as many words as possible presenting either no or minimal differences with respect to the other Sard. varieties, such as 'peus' ('worse'), 'pòpulu' ('people'), 'bufat' ('he/she drinks') and so on.

One way to extend the list of words possibly uttered in similar ways all over Sardinia was to include toponyms such as 'Bosa' and Sard. traditional first names. In the latter case, it is worth mentioning that Sard. names often present diatopic differences, such as Frantziscu, Franciscu, Vrachiscu ('Francis') and so on.[175] Hence, the best way to obtain an (almost) homogeneous cross-dialectal pronunciation of a given first name (say 'Cìciu') was to write it down directly in the Italian phrase: 'Mi chiamo *Cìciu*' ('My name is Cìciu').

Other than that, the need to have as many similar words as possible across the Sard. dialects was fulfilled, in a couple of cases, by terms that can be probably considered technical words and/or recent loans: 'architetu' ('architect') and 'bobina' ('reel'), with their derivatives 'architetura' ('architecture') and 'bobinedda' ('little reel').

The 33 phrases of the CLog. questionnaires are displayed in Table 8.

[175] This list becomes even longer if diminutives such as Cìciu, Chicu, Cicigheddu, etc. are also included.

			original Italian phrase	expected CLog. translation	expected pronunciation	English translation
labial	1	/i/	Accende la pipa	Atzendet sa p**i**pa	['βɨp·a]	'He lights the pipe'
	2	/e/	Meglio e peggio	Mezus e p**e**us	['peus]	'Better and worse'
	3	/ɛ/	Ho visto Peppa	Apo 'idu a P**e**pa	['p·ɛp·a]	'I saw Pepa'
	4	/a/	Ho visto il Papa	Apo 'idu su p**a**pa	['βaβa]	'I saw the Pope'
	5	/ɔ/	Vivo a Bosa	Vivo/isto in B**o**sa	['bɔz·a]	'I live in Bosa'
	6	/o/	Viene dal popolo	Benit dae su p**ò**pulu	['βop·ulu]	'He is a man of the people'
	7	/u/	Lui non beve	Issu no b**u**fat	['b·uf·aḍa]	'He does not drink'
dentoalveolar	8	/i/	Le fa male la tetta	Li dolet sa t**i**ta	['ḍɨt·a]	'Her breast aches'
	9	/e/	Io sono l'architetto	Deo so archit**e**tu	[aɾki't·et·u]	'I am the architect'
	10	/ɛ/	Ne ho visto sette	Nd'apo 'idu s**e**te	['z·ɛt·ɛ]	'I saw seven of them'
	11	/a/	Vivo a Sassari	Vivo/isto in T**à**tari	['tat·aɾi]	'I live in Sassari'
	12	/ɔ/	Me la bevo tutta	Mi la bufo t**o**ta	['ḍɔt·a]	'I'm drinking all of it'
	13	/o/	Mi piace tutto	Mi piaghet t**o**tu	['t·ot·u]	'I like everything'
	14	/u/	Una buona virtù	Una bona virt**u**de	[viɾ'tuḍɛ]	'A good virtue'
palatal	15	/i/	Mi chiamo Cìciu	Mi giamo C**ì**ciu	['ʧɨʧ·u]	'My name is Cìciu'
	16	/e/	Un bel progetto	Unu bellu prog**e**tu	[βɾo'ʤ:et·u]	'A good project'
	17	/ɛ/	Una donna aggesa	Una fèmina agg**e**sa	[a'ʤ:ɛz·a]	'A woman from Aggius'
	18	/a/	Tre agricoltori	Tres mass**a**jos	[ma's:adʒ·os]	'Three farmers'
	19	/ɔ/	Scendi giù	Fala a g**i**osso	['ʤɔs:ɔ]	'Get down'
	20	/o/	Mercoledì e giovedì	Mèrcuris e giòg**i**a	['ʤodʒ·a]	'Wednesday and Thursday'
	21	/u/	Non è giusto	No est g**iu**stu	['ʤustu]	'It is not fair'
labial	22	/e/AT-1	Ho visto Pepina	Apo 'idu a P**e**pina	[p·e'p·ina]	'I saw Pepina'
	23	/ɛ/AT-1	Ho visto Pepedda	Apo 'idu a P**e**pedda	[p·ɛ'p·ɛḍ:a]	'I saw Pepedda'
	24	/ɔ/ AT-1	Ho visto Bobore	Apo 'idu a B**o**bore	[b·ɔ'b:ɔɾɛ]	'I saw Bobore'
	25	/o/AT-1	È una bobina	Est una b**o**bina	[βo'b:ina]	'It is a reel'
	26	/e/AT-2	Mi chiamo Pepighedda	Mi naro P**e**pighedda	[βep·i'ɣɛḍ:a]	'My name is Pepighedda'
	27	/o AT-2	È una bobinetta	Est una b**o**binedda	[βob·i'nɛḍ:a]	'It is a tiny reel'
dentoalveolar	28	/e/AT-1	Una laurea in architettura	Una làurea in archit**e**tura	[aɾkite't·uɾa]	'A degree in architecture'
	29	/ɛ AT-1	Ne ho visto settanta	Nd'apo 'idu s**e**tanta	[zɛ't·anta]	'I saw seventy of them'
	30	/ɔ/AT-1	Una guerra totale	Una gherra t**o**tale	[ḍɔ't·alɛ]	'A total war'
	31	/o/AT-1	Mi chiamo Totoi	Mi naro T**o**toi	[ḍo't·oi]	'My name is Totoi'
	32	/e/AT-2	Mio figlio è tessitore	Fizu meu est t**e**ssidore	[t·es:i'ḍɔɾɛ]	'My son is a weaver'
	33	/o/AT-2	Mi chiamo Totoigheddu	Mi naro T**o**toigheddu	[ḍot·oĭ'geḍ:u]	'My name is Totoigheddu'

Table 8: Questionnaire for CLog. The phrases containing unstressed target vowels (i.e. 22-33) are split according to pretonic and pre-pretonic position (AT-1 and AT-2, respectively).

The expected target vowel of phrase 20, i.e. ['ʤodʒ·a], clearly constitutes a violation of the metaphony rule, as traditionally presented in the literature, in that close-mid vowels are said to be so because they are followed by a close or a close-mid vowel. Instead, the vowel [o] is

here expected to have a close-mid quality in spite of being followed by the open vowel [a]. In this respect, some remarks will be made in the Results section on the need for traditional descriptions of Sardinian metaphony to undergo a partial revision.

- Adaptation to Campidanese (Sinnai)

Consistently with the effort in finding, for CLog., as many words as possible exhibiting a similar pronunciation across the Sard. varieties, the vast majority of the phrases did not need any adjustments for the Camp. questionnaire. Among the few exceptions, a very interesting one is that of 'archit**e**tu', since this word would be pronounced in Camp. with [ɛ], in accordance with the traditional metaphony rule as applied in this Sard. variety.[176] On the other hand, the word 'archit**e**tura'[177] was included in the questionnaire, since the [u] following the target vowel is not a reduced form of a supposed etymological *[ɔ], and hence metaphonic pressure was expected to occur in this case.

Camp. was chosen by the researcher as a good candidate for gathering preliminary data on a mid vowel (i.e. /o/) in pre-pre-pretonic (henceforth AT-3) position.

The list of phrases of the Camp. questionnaire is reported in Table 9.

[176] The reason lies in the fact that this word might be perceived by Camp. speakers as an Italian loan, and consequently the original final mid vowel is reduced to [u] without activating metaphony on the preceding mid vowel. See, in this respect, Virdis 1978:78: '[nei prestiti] Le vocali di sillaba finale *-e* ed *-o* vengono trasformati in *i* ed *u* secondo la norma campidanese' ('[in loans] The final-syllable vowels *-e* and *-o* are changed into *i* and *u* according to the Campidanese rule'). One of the examples there presented is Italian 'bottone' ('button'), adapted as [buˈtːɔni], with the stressed mid vowel pronounced as open-mid right because the following [i] is not etymological. For more details on metaphony and vowel reduction in Camp., see § 2.3 above.

[177] This word has different spellings in Italian (with double 't') and in Sardinian (with single 't').

			original Italian phrase	expected Camp. translation	expected pronunciation	English translation
labial	1	/i/	Accende la pipa	Alluit sa p**i**pa	[ˈβ**i**pˑa]	‘He lights the pipe’
	2	/e/	Meglio e peggio	Mellus e p**e**us	[ˈp**e**us]	‘Better and worse’
	3	/ɛ/	Ho visto Peppa	Apu biu a P**e**pa	[ˈpˑ**ɛ**pˑa]	‘I saw Pepa’
	4	/a/	Ho visto il Papa	Apu biu su p**a**pa	[ˈβ**a**pˑa]	‘I saw the Pope’
	5	/ɔ/	Vivo a Bosa	Bivu/istu in B**o**sa	[ˈb**ɔ**zˑa]	‘I live in Bosa’
	6	/o/	Viene dal popolo	Benit dae su p**ò**pulu	[ˈβ**o**pˑulu]	‘He is a man of the people’
	7	/u/	Lui non beve	Issu non b**u**fat	[ˈbˑ**u**fˑaða]	‘He does not drink’
dentoalveolar	8	/i/	Le fa male la tetta	Ddi ‘ollit sa t**i**ta	[ˈḍ**i**tˑa]	‘Her breast aches’
	9	/e/	Prendi il coltello	Piga su cot**e**ddu	[ɣoˈtˑ**e**ḍːu]	‘Take the knife’
	10	/ɛ/	Ne ho visto sette	Nd’apu biu s**e**ti	[ˈzˑ**ɛ**tˑi]	‘I saw seven of them’
	11	/a/	Cantami un’ottava	Canta·mì un’ot**a**da	[ɔˈtˑ**a**ḍa]	‘Sing an octave’
	12	/ɔ/	Melis e Todde	Melis e T**o**dde	[ˈtˑ**ɔ**ḍːɛ]	‘Melis and Todde’
	13	/o/	Mi piace tutto	Mi praxit t**o**tu	[ˈtˑ**o**tˑu]	‘I like everything’
	14	/u/	Il vizio e la virtù	Vìtziu e virt**u**di	[vɪɾˈt**u**ḍi]	‘A bad habit and a virtue’
palatal	15	/i/	Mi chiamo Cìciu	Mi nant C**i**ciu	[ˈʧ**i**ʧˑu]	‘My name is Cìciu’
	16	/e/	Guarda il progetto	Càstia su prog**e**ttu	[βɾoˈdʒː**e**tˑu]	‘Look at the project’
	17	/ɛ/	Una donna aggesa	Una fèmina agg**e**sa	[aˈdʒː**ɛ**zˑa]	‘A woman from Aggius’
	18	/a/	Quattro nonni	Cuatru ai**a**ius	[aˈj**a**jus]	‘Four grandfathers’
	19	/ɔ/	La mano ruvida	Sa manu arrungi**o**sa	[ˈdʒ**ɔ**sːɔ]	‘The rough hand’
	20	/o/	Le pietre preziose e i gioielli	Prendas e gi**o**ias	[ˈdʒ**o**jas]	‘Gemstones and jewels’
	21	/u/	Non è giusto	No est gi**u**stu	[ˈdʒ**u**stu]	‘It is not fair’
labial	22	/e/AT-1	Ho visto Pepina	Apu biu a P**e**pina	[pˑ**e**ˈpˑina]	‘I saw Pepina’
	23	/ɛ/AT-1	Ho visto Pepedda	Apu biu a P**e**pedda	[pˑ**ɛ**ˈpˑɛḍːa]	‘I saw Pepedda’
	24	/ɔ/AT-1	Ho visto Bobore	Apu biu a B**o**bore	[bˑ**ɔ**ˈbːɔɾɛ]	‘I saw Bobore’
	25	/o/AT-1	È una bobina	Est una b**o**bina	[β**o**ˈbːina]	‘It is a reel’
	26	/e/AT-2	Mi chiamo Pepighedda	Mi nant P**e**pighedda	[β**e**pˑiˈɣɛḍːa]	‘My name is Pepighedda’
	27	/o AT-2	È una bobinetta	Est una b**o**binedda	[β**o**bˑiˈnɛḍːa]	‘It is a tiny reel’
dentoalveolar	28	/e/AT-1	Una laurea in architettura	Una làurea in archit**e**tura	[aɾkit**e**ˈtˑuɾa]	‘A degree in architecture’
	29	/ɛ/AT-1	Ne ho visto settanta	Nd'apu biu s**e**tanta	[z**ɛ**ˈtˑanta]	‘I saw seventy of them’
	30	/ɔ/AT-1	Mi chiamo Totori	Mi nant T**o**tori	[ḍ**ɔ**ˈtˑɔɾi]	‘My name is Totori’
	31	/o/AT-1	Una tartaruga	Unu tost**o**inu	[ḍost**o**ˈinu]	‘A turtle’
	31b	/o/AT-2	Una tartaruga	Unu t**o**stoinu	[ḍ**o**stoˈinu]	‘A turtle’
	32	/e/AT-2	Mio figlio è tessitore	Fillu miu est t**e**ssidori	[t**e**sːiˈḍɔɾi]	‘My son is a weaver’
	33	/o/AT-3	Una tartarughina	Unu t**o**stoineddu	[ḍ**o**stoiˈnˑeḍːu]	‘A little turtle’

Table 9: Questionnaire for Camp. This variety is the only one presenting a target vowel in AT-3 position (phrase 33). ‘Melis e Todde’ in phrase n. 12 are Sard. surnames.

A further change on the Camp. questionnaire concerned the version read by the informant Camp_05. This change was introduced after the first four Campidanese informants, when

translating the Italian phrase ‘le pietre preziose e gioielli’, modified the syntactic structure of the phrase, turning it from the expected ‘prendas e gi**o**ias’ into ‘gi**o**ias e prendas’ because this outcome sounded more familiar to them. This syntactic shift caused the target vowel to be uttered in the left section of the phrase and to present a clearly higher F0 than the corresponding target vowels in the right section. In this respect, the possibility for on-line formants to shift as a function of F0 has been studied for Czech speakers by Chládková et al. (2009), and, in general terms, higher F0 values were seen there to cause F1 and F2 also to be higher. Yet, a shown by Figs. 2 and 3 of the study in question, this formant shift as a function of F0 affected F1 of female speakers, while in men’s F1 hardly any changes could be detected as a function of F0 shift.

An easy way to evaluate in the present work the possible effect of higher vs. lower F0 on F1 and F2 in Camp. ‘gi**o**ias’ was to show the informant Camp_05, in the questionnaire, the two following Italian phrases:

20: ‘i gioielli e le pietre preziose’
20b: ‘le pietre preziose e i gioielli’

As a result, the speaker translated phrase 20 as ‘gi**o**ias e prendas’ (6 times), consistently with the nearly lexicalised Camp. phrase pronounced by the other informants, and the phrase 20b as ‘prendas e gi**o**ias’ (6 times). The mean formant frequency values of the two sets of [o] in the pal. context were then compared, so as to evaluate whether a higher F0 in the first set actually caused F1 and F2 to be higher then the respective formants of the second set, where F0 was clearly lower. The results are reported and discussed below in § 6.2.1.

- Adaptation to Nuorese (Fonni)

Compared to the original set of phrases for CLog., the Nuor. variety spoken in Fonni – as in the case of Camp. – did not require many lexical changes. A couple of them were due to an apparently minor phonetic feature differentiating Fonnese and the varieties spoken in other areas of central Sardinia from other Sard. varieties, namely the conservation of the interdental voiceless fricative [θ].[178] For example, the toponym ‘Tàtari’ is pronounced, in Fonnese, as

[178] For a brief description of the acoustic characteristics and diatopic distribution of [θ] in Sardinian, see Contini 1987:227–230 and Contini, 1987b, Table 17.

[ˈθaθaɾi], with stressed [a] embedded in an interdental context, whereas the same word is pronounced in CLog. and NLog. as [ˈtat·aɾi]. The former realisation is not fully compatible with the criteria described above in § 5.3, since the voiceless fricative [θ] was merely considered a possible substitute of [t], but at the same time each target vowel is required to be flanked by at most one substitute, not two, as would happen instead in [ˈθaθaɾi]. Accordingly, the more suitable word [kanˈtaḍa] was chosen instead. The list of phrases of the Nuor. questionnaire is given in Table 10.

			original Italian phrase	expected Nuor. translation	expected pronunciation	English translation
labial	1	/i/	Accende la pipa	Alluet sa p**i**pa	[ˈp**i**p·a]	‘He lights the pipe’
	2	/e/	Meglio e peggio	Mèngius e p**e**us	[ˈp**e**us]	‘Better and worse’
	3	/ɛ/	Ho visto Peppa	Apo bidu a P**e**pa	[ˈp·**ɛ**p·a]	‘I saw Pepa’
	4	/a/	Ho visto il Papa	Apo bidu su p**a**pa	[ˈp**a**p·a]	‘I saw the Pope’
	5	/ɔ/	Vivo a Bosa	Vivo/isto in B**o**sa	[ˈb**ɔ**s·a]	‘I live in Bosa’
	6	/o/	Viene dal popolo	Benit dae su p**ò**pulu	[ˈp**o**p·ulu]	‘He is a man of the people’
	7	/u/	Lui non beve	Issu non b**u**fat	[ˈb**u**f·aḍa]	‘He does not drink’
dentoalveolar	8	/i/	Le fa male la tetta	Li dolet sa t**i**ta	[ˈt**i**t·a]	‘Her breast aches’
	9	/e/	Un cavallo mansueto	Unu cavaddu mas**e**du	[maˈs:**e**ḍu]	‘A tame horse’
	10	/ɛ/	Ne ho visto sette	Nd’apo bidu s**e**te	[ˈs**ɛ**t·ɛ]	‘I saw seven of them’
	11	/a/	Te l’ho cantata	Ti l’apo cant**a**da	[kanˈt**a**ḍa]	‘I sang it to you’
	12	/ɔ/	Melis e Todde	Melis e T**o**dde	[ˈt·**ɔ**ḍ:ɛ]	‘Melis and Todde’
	13	/o/	Mi piace tutto	M’argadat t**o**tu	[ˈt·**o**t·u]	‘I like everything’
	14	/u/	Una buona virtù	Una bona virt**u**de	[viɾˈt**u**ḍɛ]	‘A good virtue’
palatal	15	/i/	Mi chiamo Cìciu	Mi muto C**ì**ciu	[ˈʧ**i**tʃ·u]	‘My name is Cìciu’
	16	/e/	Guarda il progetto	Bàrdia su prog**e**ttu	[pɾoˈʤ:**e**t·u]	‘Look at the project’
	17	/ɛ/	Una donna aggesa	Una ‘èmina agg**e**sa	[aˈʤ:**ɛ**s·a]	‘A woman from Aggius’
	18	/a/	Io sono il lattaio	Deo soe su lat**a**ju	[laˈt·**a**ju]	‘I am the milkman’
	19	/ɔ/	Butta la scotta	Bùlia·nche sa gi**o**ta	[ˈʤ**ɔ**t·a]	‘Throw the buttermilk away’
	20	/o/	Ecco lo yogurt	La’ su gi**o**ddu	[ˈʤ**o**ḍ:u]	‘Here is the yogurt’
	21	/u/	Non è giusto	No est gi**u**stu	[ˈʤ**u**stu]	‘It is not fair’
labial	22	/e/ AT-1	Ho visto Pepina	Apo bidu a P**e**pina	[p·**e**ˈp·ina]	‘I saw Pepina’
	23	/ɛ/ AT-1	Ho visto Pepedda	Apo bidu a P**e**pedda	[p·**ɛ**ˈp·ɛḍ:a]	‘I saw Pepedda’
	24	/ɔ/ AT-1	Ho visto Bobore	Apo bidu a B**o**bore	[b·**ɔ**ˈb·ɔɾɛ]	‘I saw Bobore’
	25	/o/ AT-1	È una bobina	Est una b**o**bina	[b**o**ˈb·ina]	‘It is a reel’
	26	/e/ AT-2	Mi chiamo Pepighedda	Mi muto P**e**pighedda	[p**e**p·iˈgɛḍ:a]	‘My name is Pepighedda’
	27	/o/ AT-2	È una bobinetta	Est una b**o**binedda	[b**o**b·iˈnɛḍ:a]	‘It is a tiny reel’
dentoalveolar	28	/e/ AT-1	Una laurea in architettura	Una làurea in archit**e**tura	[aɾkit**e**ˈt·uɾa]	‘A degree in architecture’
	29	/ɛ/ AT-1	Ne ho visto settanta	Nd’apo bidu s**e**tanta	[s**ɛ**ˈt·anta]	‘I saw seventy of them’
	30	/ɔ/ AT-1	Una guerra totale	Una gherra t**o**tale	[t**ɔ**ˈt·alɛ]	‘A total war’
	31	/o/ AT-1	Mi chiamo Totoi	Mi muto T**o**toi	[t**o**ˈt·oi]	‘My name is Totoi’
	32	/e/ AT-2	Mio figlio è tessitore	Fìgiu meu est t**e**ssidore	[t·**e**θ:iˈdɔɾɛ]	‘My son is a weaver’
	33	/o/ AT-2	Mi chiamo Totoigheddu	Mi muto T**o**toigheddu	[t**o**t·oĭˈgeḍ:u]	‘My name is Totoigheddu’

Table 10: List of phrases for the Nuor. questionnaire.

- Adaptation to Northern Logudorese

The adaptation from CLog. to NLog. only required the changing of a single word: ‘gi**u**stu’ (phrase 21 in the CLog. questionnaire). This word is in fact pronounced in NLog. as [ˈʤ**u**ɬtu], with a monolateral fricative following the target vowel, and had to be replaced because [ɬ] was not among the possible candidates to substitute a missing palatal consonant. Hence, the word ‘agiudu’, with the expected pronunciation [aˈʤˑ**u**ɖu], was chosen instead, as shown in Table 11.

			original Italian phrase	expected NLog. translation	expected pronunciation	English translation
labial	1	/i/	Accende la pipa	Atzendet sa p**i**pa	[ˈβ**i**pˑa]	‘He lights the pipe’
	2	/e/	Meglio e peggio	Mezus e p**e**us	[ˈp**e**us]	‘Better and worse’
	3	/ɛ/	Ho visto Peppa	Apo ‘idu a P**e**pa	[ˈpˑ**ɛ**pˑa]	‘I saw Pepa’
	4	/a/	Ho visto il Papa	Apo ‘idu su p**a**pa	[ˈβ**a**βa]	‘I saw the Pope’
	5	/ɔ/	Vivo a Bosa	Vivo/isto in B**o**sa	[ˈb**ɔ**zˑa]	‘I live in Bosa’
	6	/o/	Viene dal popolo	Benit dae su p**ò**pulu	[ˈβ**o**pˑulu]	‘He is a man from the people’
	7	/u/	Lui non beve	Issu no b**u**fat	[ˈbˑ**u**fˑaḍa]	‘He does not drink’
dentalveolar	8	/i/	Le fa male la tetta	Li dolet sa t**i**ta	[ˈḍ**i**tˑa]	‘Her breast aches’
	9	/e/	Io sono l’architetto	Deo so archit**e**tu	[aɾkiˈtˑ**e**tˑu]	‘I am the architect’
	10	/ɛ/	Ne ho visto sette	Nd’apo ‘idu s**e**te	[ˈzˑ**ɛ**tˑɛ]	‘I saw seven of them’
	11	/a/	Vivo a Sassari	Vivo/isto in T**à**tari	[ˈt**a**tˑaɾi]	‘I live in Tàtari’
	12	/ɔ/	Me la bevo tutta	Mi la bufo t**o**ta	[ˈḍ**ɔ**tˑa]	‘I’m drinking all of it’
	13	/o/	Mi piace tutto	Mi piaghet t**o**tu	[ˈtˑ**o**tˑu]	‘I like everything’
	14	/u/	Una buona virtù	Una bona virt**u**de	[viɾˈt**u**ḍɛ]	‘A good virtue’
palatal	15	/i/	Mi chiamo Cìciu	Mi giamo C**ì**ciu	[ˈʧ**i**ʧˑu]	‘My name is Cìciu’
	16	/e/	Un bel progetto	Unu bellu prog**e**tu	[βɾoˈʤː**e**tˑu]	‘A good project’
	17	/ɛ/	Una donna aggesa	Una fèmina agg**e**sa	[aˈʤː**ɛ**zˑa]	‘A woman from Aggius’
	18	/a/	Tre agricoltori	Tres mass**a**jos	[mˑaˈsː**a**ʒˑɔs]	‘Three farmers’
	19	/ɔ/	Scendi giù	Fala a gi**o**sso	[ˈʤ**ɔ**sːɔ]	‘Get down’
	20	/o/	Mercoledì e giovedì	Mèrcuris e gi**ò**gia	[ˈʤ**o**ʒia]	‘Wednesday and Thursday’
	21	/u/	Ti do un aiuto	Ti do un agi**u**du	[aˈʤˑ**u**ḍu]	‘I am going to help you’
labial	22	/e/ AT-1	Ho visto Pepina	Apo ‘idu a P**e**pina	[pˑ**e**ˈpˑina]	‘I saw Pepina’
	23	/ɛ/ AT-1	Ho visto Pepedda	Apo ‘idu a P**e**pedda	[pˑ**ɛ**ˈpˑɛḍːa]	‘I saw Pepedda’
	24	/ɔ/ AT-1	Ho visto Bobore	Apo ‘idu a B**o**bore	[bˑ**ɔ**ˈbːɔɾɛ]	‘I saw Bobore’
	25	/o/ AT-1	È una bobina	Est una b**o**bina	[β**o**ˈbːina]	‘It is a reel’
	26	/e/ AT-2	Mi chiamo Pepighedda	Mi naro P**e**pighedda	[β**e**pˑiˈɣɛḍːa]	‘My name is Pepighedda’
	27	/o/ AT-2	È una bobinetta	Est una b**o**binedda	[β**o**bˑiˈnɛḍːa]	‘It is a tiny reel’
dentoalveolar	28	/e/ AT-1	Una laurea in architettura	Una làurea in archit**e**tura	[aɾkit**e**ˈtˑuɾa]	‘A degree in architecture’
	29	/ɛ/ AT-1	Ne ho visto settanta	Nd’apo ‘idu s**e**tanta	[z**ɛ**ˈtˑanta]	‘I saw seventy of them’
	30	/ɔ/ AT-1	Una guerra totale	Una gherra t**o**tale	[ḍ**ɔ**ˈtˑalɛ]	‘A total war’
	31	/o/ AT-1	Mi chiamo Totoi	Mi naro T**o**toi	[ḍ**o**ˈtˑoi]	‘My name is Totoi’
	32	/e/ AT-2	Mio figlio è tessitore	Fizu meu est t**e**ssidore	[tˑ**e**sːiˈḍɔɾɛ]	‘My son is a weaver’
	33	/o/ AT-2	Mi chiamo Totoigheddu	Mi naro T**o**toigheddu	[ḍ**o**tˑoïˈgeḍːu]	‘My name is Totoigheddu’

Table 11: Questionnaire for NLog. It is almost identical to that for CLog., with the only exception being the target word in phrase 21 (‘giustu’ in the CLog. questionnaire).

5.4 Data recordings

The corpus of data was obtained by means of field interviews carried out by the author of the present study, in offices or in the informants' houses, in the quietest and most acoustically suitable locations.

The informants were asked to read and translate into their native language the meaningful Italian phrases of the questionnaire, expressing themselves as naturally as possible. In order to achieve this, many paralinguistic and ambient factors were taken into account before and during each interview.

First, the recording started some minutes after the electronic equipment was set up, so as to give the informants some time to get comfortable with the headphones. During the preparatory phase, participants were given all the time they needed to translate the Italian phrases, a task that was carried out quite easily by all of them since they were perfectly bilingual in Algherese and Italian (Algh. informants) or Sardinian and Italian (informants from the rest of Sardinia); the only pauses during the translation were due to their desire to find possible synonyms for words they had already translated or to look for possibly more genuine Algh. or Sard. terms.

The Italian phrases were all short declaratives and for the most part contained words easily translatable into Algh. and the Sard. varieties. Such ease of translation actually caused perplexity in some of the informants, who asked the interviewer if the task was really as easy as it seemed, and this was probably the principal reason why they sometimes stopped to look for synonyms.

The interviewer mainly interacted with the informants during the phase preceding the interview, when the instructions for the task were also given, and after the end of the recordings. In some cases the informants were reminded of some of the initial instructions between the end of one series and the beginning of the next.[179]

[179] For example, some interviewees were reminded that the task did not require them to search for synonymic forms in the Algh. and Sard. translations of the phrases.

Recordings normally took place after some practice. All 25 informants were asked to read the list of phrases (21 for Algh. and 33 for the Sard. varieties) six times, and the five best series of each target word were used for measurement.

Data were recorded using an AKG C 555 L headset microphone, an AKG PT 40 pocket transmitter and an AKG SR 40 Single stationary receiver, all connected to an M-Audio MobilePre audio interface and to a laptop. Recordings and analysis were carried out by means of the Praat audio analysis software (version 5.2.22). Formant frequency measurements were performed on spectrographic displays using the following parameter values: number of formants: 6; window length: 0.025; dynamic range: 30.0 dB.

5.5 Data analysis

5.5.1 Total number of vowel realisations under analysis

The number of vowel realisations analysed in a stressed context amounted to 2,630, consisting of: 7 vowels x 3 consonantal contexts x 5 repetitions x 25 speakers, + 5 extra realisations by the speaker Camp_05.

With regard to unstressed vowels, the number of realisations analysed was 1,215 (i.e. slightly less than the expected 1,225), consisting of: 12 vowels x 5 repetitions x 15 informants (CLog., Nuor., NLog.) + 13 vowels x 5 repetitions x 5 speakers (Camp.). The 10 missing realisations were vowels which underwent processes of phonological assimilation ('P[e]pina' was pronounced 'P[i]pina' in four cases) and phonological vowel reduction (one case of 'b[o]bina' pronounced 'b[u]bina'), exhibited synonymy (in two cases the expected 'gherra t[ɔ]tale' became 'gherra de t[o]tus' and in one case 'bobina' became 'gròmmeru'), or were pronounced at a fast speech rate (one occurrence of '**to**tale' and one of '**e**pighedda' hardly showed any steady state and therefore could not be analysed instrumentally). The recording of an extra series of utterances (which was normally the first set recorded) gave the researcher the chance to substitute, in some cases, realisations considered unsuitable (e.g. unrequired synonyms); this strategy contributed to limit to just 10 the number of empty slots in the analysis of unstressed vowels.

The total number of vowels (stressed + unstressed) analysed was 3,845.

5.5.2 Spectroacoustic correlates of vowel articulation

In this study it is assumed that spectroacoustic data can be associated, to a certain extent, to the articulatory characteristics of the vowels under investigation. More specifically, and consistently with the traditional literature on experimental phonetics,[180] the first formant frequency or F1 will be considered here as a major correlate of intensity and especially of articulatory opening, and the second formant frequency or F2 as mainly related to lip rounding and especially tongue fronting.[181] Consequently, changes in F1 will be interpreted in terms of vertical movements of the tongue and jaw, in that a lower F1 will be associated with a smaller gap between the tongue dorsum and the hard palate, and with less jaw opening, and vice versa, while F2 shifts will be assumed to be indicative of horizontal lingual movements, in that a lower F2 should correspond to a more retracted position of the tongue body, and vice versa.

5.6 Vowel segmentation and formant measurements

Each vowel boundary was determined in accordance with the onset and offset of the vowel formants following and preceding the closure period for plosives, the frication period for fricatives and the low intensity boundaries for approximants. When target vowels were embedded in a pal. context including the approximant [j] and (only in one case) [i], or in a lab. context (including in one case the vowel [u]), the author's auditory impression was also used to better define boundaries. The same criteria used for the segmentation of stops and fricatives were also applied to affricates.

Once each vowel boundary and the corresponding duration were determined, the vowel midpoint (M) was calculated using the formula $M = (x_i + x_f)/2$, where x_i and x_f stand for the beginning and the end of the vowel, respectively. The first three formants (F1, F2 and F3) were then manually measured by placing a cursor along the vowel midpoint, coinciding with the centre of each formant.

5.6.1 Stressed vowels

Generally speaking, the data analysis criteria set out in the previous section were applied both to stressed and unstressed vowels, but the two series were further analysed in partially

[180] See Giannini & Pettorino, 1992/2003.
[181] See Fant, 1960.

different ways so as to better pursue the different goals for which they were required. Stressed vowels were, in fact, needed to evaluate whether Algh. vowels still acoustically resemble those of other Cat. varieties or whether, by contrast, they have been diachronically affected by Sard. varieties (Chapter 1). Stressed vowels are also required to test two predictions of the Adaptive Dispersion Theory concerning the correlation between vowel system size and vowel dispersion and variability (Chapter 2). Unstressed vowels, on the other hand, were recorded and analysed in order to fulfil the goal introduced in Chapter 3, i.e. the testing of the centralisation-based and undershoot-based models against data for Sard. unstressed mid vowels.

The analysis procedure for stressed vowels will be described in the following sections 5.6.1.1–5.6.1.4, while the corresponding procedure for unstressed vowels will be dealt with in sections 5.6.2.1–5.6.2.2.

5.6.1.1 Application of the normalisation formula (CLIH)

To better cope with individual differences due to the vocal anatomy of speakers, and to better compare vowel formants across different dialects/languages, a speaker normalisation procedure was carried out for the first three formants.

The Constant Logarithm Interval Hypothesis (CLIH) proposed by Nearey (1978) was here considered to be the most suitable normalisation method. This choice required a preliminary theoretical evaluation of the vowel inventory size of the languages/dialects included in the present work. In fact, as seen in Chapter 2 with regard to the Sard. varieties, defining the vowel inventory size might depend on the more phonetic or phonological meaning which is attributed to the definition 'vowel inventory size'. On the one hand, in all the Sard. varieties the vowel allophones tend to gather towards seven different areas (Contini & Böe, 1972; Contini, 1987; Molinu, 1997/2009) but, on the other, only Camp. presents seven contrastive vowels. In this respect, CLIH is characterised for being a vowel-extrinsic method of data normalisation, in that it uses acoustic information distributed across all the vowels produced by a given speaker. For these reasons, it was believed that this method could work better for the Sard. varieties if the values belonging to all the seven phonemes/allophones, i.e. /i/, /ɛ/, /a/, /ɔ/, /u/ + /e/ or [e] and /o/ or [o], were included.

The normalisation formula is CLIH = $F^*_{N[V]s}$ = $G_{N[V]s}$ - $G_{.[.]s}$, where $F^*_{N[V]s}$ is the measurement in Hz of the Nth formant of vowel V for subject s, and *G* is the natural logarithm. The natural logarithm of the mean formant frequency across vowels was subtracted from the natural logarithm of the formant frequencies for the individual vowels. Normalised vowel formant frequencies for each speaker were obtained by averaging the normalised formant frequencies across all vowel repetitions and contextual conditions, and those for each dialect by averaging the normalised vowel formant frequencies across repetitions, contexts and speakers.[182]

5.6.1.2 Acoustic differences between Algherese stressed vowels and their correspondents in other Catalan and Sardinian varieties

As anticipated above in Chapter 1, the first aim of the present study will be pursued by comparing both the 1) frequency values and 2) vowel durations for the Algh., mCat. and the Sard. varieties.

1) Formant frequency

Once the mean formant frequency values (F1, F2 and F3) for Algh. and Sard. vowels were computed, they were compared to the correspondent values for the mCat. varieties extracted from R&E (2006:652).

The first general formant comparison was carried out between Algh. and Sard. (cross-dialectally) and between Algh. and mCat. (cross-dialectally), so as to establish whether the Algh. stressed vowels tend to acoustically converge more towards the Sard. or the mCat. ones.

The second comparison concerned Algh., and the individual Sard. and Cat. varieties, and was carried out using the *mean F1 distance* (1a) and the *mean F1xF2 Euclidean distance* (1b):

1a) the *mean F1 distance* was calculated by averaging the absolute F1 differences between each of the seven Algh. vowels and their cognates in the other varieties under investigation;

[182] As an example, in the case of the speaker Algh_01, the natural logarithm was calculated for each of the seven vowels, and yielded the values 5.829 (340 Hz) for /i/, 6.070 (433 Hz) for /e/, 6.284 (536 Hz) for /ɛ/, 6.689 (803 Hz) for /a/, 6.261 (524 Hz) for /ɔ/, 6.101 (446 Hz) for /o/ and 5.867 (353 Hz) for /u/. The CLIH value for each vowel was obtained by subtracting the natural logarithm for each vowel (5.829, 6.070 and so forth) from the mean value across the natural logarithms for the seven vowels (6.157). The same procedure was then applied to assess the CLIH values for F2.

1b) the *mean F1xF2 Euclidean difference* was calculated by averaging the Euclidean differences, in Hz, between each of the seven Algh. vowels and their cognates in the individual Sard. and mCat. varieties.

All the procedures described in the current section were also applied to the normalised (CLIH) data.

Normalised formant frequency data were assessed statistically[183] with one-way ANOVAs performed on all vowels' data with 'dialect' as the independent variable. Two sets of ANOVAs were run on the data for Algh. and mCat., and on those for Algh. and the Sard. varieties. The number of ANOVAs for each of the two testing groups was 14 (7 vowels x 2 formants), and each ANOVA was run on 75 frequency values (3 consonantal contexts[184] x 5 speakers x 5 dialects).

To better fulfil the first aim of the present study, Tukey's pairwise comparisons were also carried out in order to elicit significant effects between the vowels of Algh. and the corresponding vowels of the individual mCat. and Sard. varieties.

2) Vowel duration

The second factor taken into account in comparing Algh. vowels with the corresponding vowels in Sard. and mCat. was duration. Once vowel segmentation had been carried out following the procedure described above in § 5.6, three mean values (i.e. one for each consonantal context) were computed for each vowel of the individual varieties. Mean duration differences between Algh. and each Sard. variety were then assessed by running one-way ANOVAs on each vowel's data with 'dialect' as the independent variable. Seven ANOVAs (one for each vowel) were performed on 75 mean duration values (3 consonantal contexts x 5 speakers x 5 dialects); Tukey's pairwise comparisons were also carried out. Statistical comparisons could not be performed between Algh. and the mCat. varieties, since no detailed information was available for the mCat. vowel durations. This said, a more 'intuitive' interpretation of the difference in duration between Algh. and the mCat. varieties will

[183] The statistical analyses were carried out using the PAST software package, version 2.17b (Hammer, Ø., Harper, D.A.T., Ryan, P.D., 2001. PAST: Palaeontological Statistic software package for education and data analysis. Palaeontologica Electronica 4(1): 9 pp.).
[184] The contextual values for mCat. were made available to the author of the present study by the authors of R&E 2006. The mCat. consonant context /l, r/ was not included in the ANOVA.

nonetheless be proposed by comparing the mean vowel duration values for the varieties in question.

The significance level for the ANOVAs carried out on both formant frequencies and vowel durations (i.e. points '1' and '2', respectively, of the current section) was fixed at $p < 0.05$. The two p values < 0.01 and < 0.001 were also included to indicate higher significance levels.

5.6.1.3 Vowel space dispersion

Measurement of vowel space dispersion was required for testing the first ADT prediction discussed in § 2.1 above (concerning the hypothesis that more crowded systems should be more expanded than less crowded ones), and was computed in terms of *point-vowel area*. The latter was obtained by calculating the space encompassed by the point vowels /i, u, a/ using Heron's formula $T=\sqrt{s(s-a)*(s-b)*(s-c)}$, where T stands for the area of the triangle, a, b and c for each side length, and s for the semiperimeter (i.e. $(a+b+c)/2$). Point-vowel areas were computed for Algh. and the individual Sard. varieties on the basis of the formant data, both unnormalised and normalised, collected in the present work. Furthermore, the same calculations were carried out on the formant frequency data for the individual Cat. varieties extracted from R&E (2006), Tables 2 and 3.

Additionally, vowel system expansion was also computed for the Sard. varieties in terms of *mean Euclidean distances*, in accordance with the following procedure:

1) definition of the *centroid* or *grand mean*. The centroid was defined by averaging the F1xF2 values across all the target vowels of a specific dialect;

2) calculation of the *Euclidean distance* between the mean F1xF2 values of a given vowel (e.g., [a]) in a given context (e.g., lab.) and a given dialect, and the corresponding F1xF2 values of the centroid; repetition of the same procedure for each of the two other consonantal contexts (i.e. dent. and pal.); repetition of the same procedure for the other six vowels (three contexts each);

3) calculation of the mean values for the twenty-one (i.e. 3 contexts x 7 vowels) Euclidean distances obtained. The same procedure was also followed for the normalised values.[185]

Comparing vowel space dispersion for the Sard. varieties also in terms of the mean Euclidean distances is considered here to be the most suitable method to test the possibility, referred to in § 2.5, of the original Camp. system having somewhat expanded during a given time period T1-T2 on the basis of the creation of a limited number of word minimal pairs, such as '[o]ru' – '[ɔ]ru' and 'b[e]ni' – 'b[ɛ]ni' (see § 2.3 and § 2.4). This analysis will of course be indirect, in that no information is available for the Camp. system at time T1 (possibly in the Middle Ages), i.e. before the process of Camp. phonological vowel reduction had started.[186] Nonetheless, according to the ADT prediction in question, if the Camp. vowel space turns out to be greater than that of the other Sard. varieties under investigation it is possible to hypothesise that the former dialect has undergone a diachronic expansion of its vowel space at time T2, which is in accordance with an increase in the number of contrasting vowels in the period T1-T2.

5.6.1.4 Vowel variability

The second ADT prediction discussed in § 2.1 claims that vowels belonging to more crowded inventories should exhibit less coarticulatory variation. This was first tested by computing contextual variability as a function of dialect. For this purpose, standard deviations were calculated for each vowel over the contextual means across repetitions and speakers for the Algh. and individual Sard. dialects (dialect-dependent contextual variability).

Context-dependent variability was also assessed by computing standard deviations for each vowel over contextual means across repetitions, speakers and dialects (i.e. across Algh. and the Sard. varieties).

[185] As an example, let us consider the procedure used to assess the mean Euclidean distance in NLog. Following point (1) above, the mean value for both F1 and F2 across conditions (i.e. 5 tokens x 3 consonantal contexts x 7 vowels x 5 speakers) yielded 480 Hz and 1457 Hz, respectively, which constituted the F1 and F2 of the centroid for the variety in question. Following the example given in point (2), the next step was to assess the mean F1 and F2 for each vowel in a given consonantal context across tokens and speakers; thus, in NLog., the F1 and F2 values for /a/ in the lab. context were 742 Hz and 1285 Hz, respectively. Then the Pythagorean theorem was applied to the differences between the vowel formant values in the context of interest and the centroid and the resulting value was the Euclidean distance for that context. In the example under consideration, the Euclidean distance amounted to 314 Hz.

[186] As regards the role of phonological reduction in increasing the number of contrasting vowels in Camp., see above § 2.3.

Finally, mean contextual F1xF2 values for each vowel across repetitions and speakers of Algh. and the individual Sard. and mCat. varieties were compared so as to evaluate whether the degree of context-dependent variability also varies as a function of other variables, such as 'language/dialect', 'place of articulation of the adjacent consonants', 'vowel quality' and 'direction of formant frequency shifts'. A reliable way of testing whether the variable 'language/dialect' can itself affect the degree of coarticulation was to compare the degree of context-dependent variability among varieties presenting an identical number of contrasting vowels, such as CLog. and NLog.

The variable 'place of articulation of adjacent consonants' was evaluated by graphically plotting the mean contextual values for different languages/varieties. An easy way to isolate this variable was to look for recurrent context-dependent variability patterns across different systems. The same strategy also permitted the evaluation of coarticulatory resistance[187] for the individual vowels. Further information about the direction of formant frequency shifts was gathered by means of ellipses with radii of two standard deviations drawn along axes oriented along the principal components of each vowel cluster.[188]

5.6.2 Unstressed vowels

Unstressed target vowels were specifically recorded for the Sard. varieties so as to verify whether and to what extent acoustic vowel reduction in this language follows formant patterns predicted by the undershoot-based model (UBM) and the centralisation-based model (CBM). In § 3.3 it was hypothesised, according to data from Contini (1987) and preliminary formant measurements carried out on our corpus, that the degree and direction of acoustic reduction for Sard. unstressed vowels might also depend on phonological factors.

The procedure used to define formant differences between stressed and unstressed vowels is briefly described in § 5.6.2.1, whereas the analysis procedure to account for possible language-dependent factors in explaining the dynamics of acoustic vowel reduction in the Sard. varieties will be dealt with in § 5.6.2.2.

[187] 'Coarticulatory resistance' is used here to indicate the degree of variability in formant frequency attributable to the coarticulatory influence of flanking segments. The lesser the variability degree, the more resistant the vowel.
[188] The ellipses were drawn using the software JPlotFormants, version 1.4 (2002).

5.6.2.1 Formant differences between stressed and unstressed Sardinian vowels

The first two formants (F1, F2) of the mid vowels /e, ɛ, o, ɔ/ were measured in the AT-1 position, in both lab. and dent. contexts for each Sard. variety. A similar procedure was followed to measure the first two formants of the close-mid vowels /e, o/ at AT-2. Once the mean values for unstressed mid vowels were computed, they were compared to the TO correspondents in similar consonantal contexts. In other words, given that AT vowels were only obtained in the dent. and lab. environments, the corresponding values for their stressed cognates were computed solely in the dent. and lab. contexts (thus excluding vowels flanked by palatal consonants). The formant measurements for the only vowel sample at AT-3 (in Camp.) were exclusively carried out for /o/dent., due to lexical restrictions; the results were then compared to those for stressed /o/ at AT-1 and AT-2 in the same consonantal context (dent.) and the same dialect (Camp.).

5.6.2.2 Evaluation of possible exceptions to metaphony rule

When the first formant measurements of unstressed vowels were carried out, clear cases were found of exceptions to the Sard. metaphony rule. To mention just one exception, the first name 'P**e**pina' (with target vowel in the AT-1 position) was uttered in some cases as 'P[ɛ]pina', in spite of the target vowel being followed by the close vowel /i/. In other cases, the vertical formant shift caused the mid vowel to be rather centralised, making it difficult to definitely ascertain if the realisation in question was classifiable as open-mid or close-mid. To cope with this problem, an *ad hoc* method of data analysis was drawn up to qualitatively and quantitatively analyse possible exceptions to Sard. metaphony, and to also correctly classify all the vowels produced as much centralised on the vertical dimension. It is generally assumed that the first formant (F1) is the major correlate of the degree of opening of a vowel, hence it seems natural that a possible boundary between close-mid and open-mid vowels should be specified in terms of their position along the F1 dimension. Since another well known fact is that the acoustic properties of a vowel might change as a function of speaker, consonant context, dialect and so on, each comparison between a given unstressed mid vowel and its stressed referent has been carried out here by taking into account all these variables as separate. For this purpose, the mean F1 values of a given vowel (say [e]), produced in a specific consonantal environment (say in the dent. context) by a specific speaker (say CLog_01) have been compared to the stressed correspondent produced by the same speaker in the same CVC context.

Although a simple acoustic comparison between a given unstressed vowel and its stressed cognate can give us information about possible absolute formant differences, an objective boundary is still needed to establish when a close-mid vowel has been effectively uttered as an open-mid vowel, and vice versa. With regard to the specific example of a given unstressed [e] in the dent. environment produced by speaker CLog_01, the easiest way to find such boundary would be simply to compute the F1 average between stressed [e] and its open-mid counterpart [ɛ] from the same speaker in the same consonantal context, and to use the result as a threshold over which the vowel should be considered as open-mid and vice versa. To put it in figures, given that the informant CLog_01 (i.e. informant number one for Common Logudorese) produced stressed [e] in the dent. context with a mean F1=438 Hz, and /ɛ/ in the same context with a mean F1=525 Hz, the midpoint *M* on the vertical axis would be 482 Hz (i.e. *M*=(438+525)/2). Consequently, once this threshold midpoint is established, it could be possible to claim that every given 'e', uttered by the same speaker, in a similar CVC context and with an F1 higher than 482 Hz (i.e. 490 Hz, 500 Hz and so on) has to be considered as open-mid, while, by contrast, it has to be treated as close-mid if the same value is lower than 482 Hz (i.e. 470 Hz, 460 Hz, and so on).

A strict application of this method would not, however, give us any margin to understand when a mid vowel has clearly 'jumped' over its expected quality (for example, when an expected [e] is uttered as [ɛ], and vice versa), or, on the contrary, when it should be considered, for the sake of prudence, as an intermediate realisation between [e] and [ɛ]. With specific reference to the [e] mentioned right above, one might argue that an F1 amounting to 485 Hz, or (say) 488 Hz and so on, produced by the same speaker might still be reasonably considered as the first formant of an 'intermediate' vowel rather than of an open-mid one, given the fact that it would be perceptually very difficult to definitely ascertain if that vowel is close-mid or open-mid.

Of course, trying to define an 'intermediate' zone in perceptual terms might not be an easy task, and different parameters in this respect have been proposed in the literature. Mermelstein (1978) found F1 *difference limens*[189] (henceforth DL) of mean values for /i/ of ≈ 50 Hz and for the boundary between /ɛ/ and /æ/ of roughly 50 Hz, but in the latter case considerable

[189] The concept of *difference limen* for steady-state vowels has been described by the author as the reflection of 'the ability of the whole auditory system to differentiate complex stimuli with stationary spectral patterns'. See Mermelstein, 1978:572.

differences were found between the synthetic speech signals simulating an isolated vowel – mean DL = 33 Hz – and signals simulating a vowel flanked by symmetrical consonants – mean DL = 70 Hz.[190]

A 50 Hz F1 is also the value below which, according to Labov's data on American English near-mergers (i.e. vowels which can be distinguished in production but not in perception), two neighbouring mid vowels cease to be contrastive.[191] Other scholars indicate much lower discriminant values for a given F1 of 500 Hz (i.e. roughly between 10–15 Hz),[192] and attribute discrepancies of estimated DL in the previous literature to the different methods adopted by researchers.[193]

To our knowledge, no studies have been published to date on DL for Sard. speakers. Consequently, it has been decided to use here, as a framework of reference, the values proposed by Flanagan (1955), who set the DL for an F1=500 at 25 Hz, i.e. around halfway between the highest and lowest DL proposed by the authors cited in the present section. For practical reasons the value of 25 Hz was here rounded up to 30 Hz, so as to consider the 'intermediate zone' as the range of ±15 Hz surrounding the arithmetical mean between a close-mid and an open-mid vowel.

When this method is applied to the example given above for speaker CLog_01, if the arithmetical F1 mean of stressed [e]dent. and [ɛ]dent. was found to be 482 Hz, it follows that the 'intermediate' zone should spread from 467 Hz (i.e. 482 Hz - 15) to 497 Hz (i.e. 482 Hz + 15). In practical terms, every time F1 values of [e] and [ɛ] in the dent. context for the same speaker were included in this area, the vowel was considered to be 'intermediate' (='interm.'). By contrast, every time F1 values crossed this central area ([e] > 497 Hz, and [ɛ] < 467 Hz), each affected vowel was considered to have 'jumped' into the acoustic space of the other one. Consequently, both these cases will be indicated in the following chapters as *jumps*, and they will be considered exceptions to the metaphony rule or to the normal realisations of Sard. mid vowels (the procedure described so far is summed up in Fig. 18).

[190] *Ibid*. The reported values are contained in Tables 2 and 3.
[191] See Labov, 1994:360–364.
[192] See Hawks, 1994 and Kewley-Port, 1990. The former author suggests a DL of ≈ 1.9 % for F1 and F2, and the latter proposes a mean value of 14 Hz for F1.
[193] See Hawks, 1994.

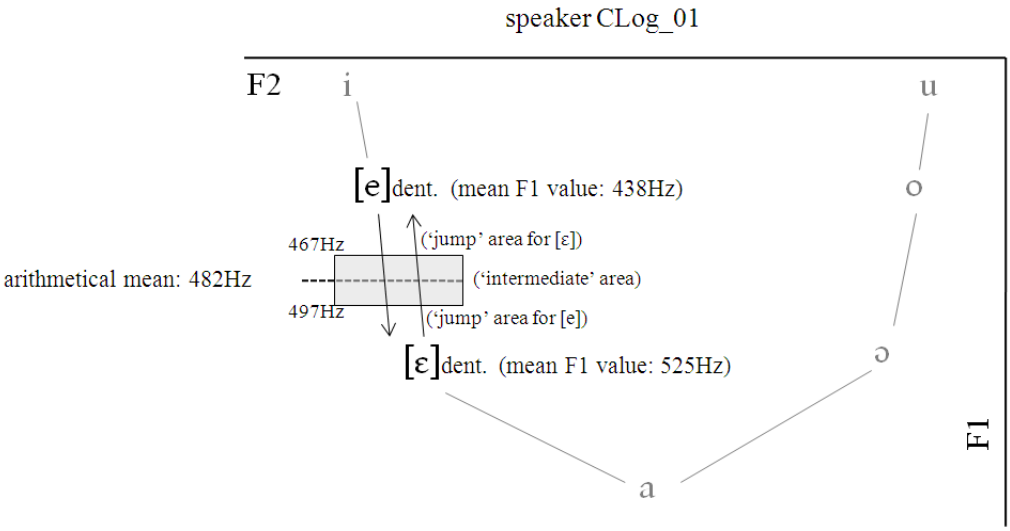


Figure 18: Scheme of discriminant formant frequency values for unstressed [e] and [ɛ] in the dental context by speaker CLog_01. The grey rectangle between [e] and [ɛ] indicates the formant range (±15 Hz from the arithmetical mean) chosen to define an unstressed mid vowel realisation as *intermediate*, and over which a given realisation of the same vowel will be considered to have 'jumped' out of its own predicted acoustic space (='jump').

The same procedure was also applied to the other unstressed vowels uttered by the same speaker, and all corresponding unstressed vowels uttered by other speakers.

The percentage of jumps was further analysed as a function of:

- 'AT-x' position (i.e. AT-1 vs. AT-2 and, only for Camp., AT-1 vs. AT-3) of the target vowel(s);

- 'vowel quality'. This analysis was aimed at evaluating whether jumps were more frequent a) among expected close-mid or open-mid vowels and b) among mid-front or mid-back vowels;

- 'vowel duration'. Two aspects were investigated in this respect: differences in duration between Sard. stressed and unstressed vowels, so as to discern whether the normally shorter articulation of the latter segments can contribute to the increase in the percentage of jumps; and whether the target vowels pronounced as jumps did present a different duration from the corresponding vowels not pronounced in this way.

Some further specific procedures for analysing the data on Sard. unstressed mid vowels will be discussed in §§ 6.4.1–6.4.3.3.

Chapter 6

Results and discussion

The data concerning the three main aims of the present dissertation will be presented and discussed in this chapter as follows: sections 6.2.1–6.2.3 provide results relevant to the hypothesis that Algherese vowels have somehow acoustically changed over the centuries from their Catalan origin quality towards a more Sardinian-like quality. The data concerning the second aim of the present dissertation, i.e. the testing of two ADT predictions against data from Catalan and Sardinian varieties, will be dealt with in sections 6.3.1–6.3.4. Finally, the data on acoustic reduction of Sardinian mid vowels will be discussed in sections 6.4.1–6.4.4.

6.1 Differences between expected and actually obtained vowel productions

In § 5.3.2 an example was given of a phrase uttered in a rather different manner from that expected, namely the Italian phrase '*Le pietre preziose e i gioielli*', translated by Camp. speakers with a syntactic shift causing the target Sard. word 'g**io**ias' to be pronounced in the left section of the phrase rather than in the right. As anticipated above in the same section, an ongoing change had to be made in the same questionnaire in order to evaluate the possible effects of an F0 shift on the first and second formant frequencies of the close-mid vowel [o] in the target word.

Other differences with respect to the expected pronunciation of target vowels were also found, but, unlike in the case of 'Gi**o**ias e prendas', they did not require any ongoing modification of the questionnaire or of the data analysis procedure, since they still met the needed contextual requirements. For example, the expected NLog. [maˈsː**aʒ**ɔs] was uttered as [maˈsː**aj**ɔs] in some cases, with [ʒ] becoming [j], but even in the latter case the target vowel [a] was still embedded in the required pal. context.

6.2 Spectral and duration characteristics of Algherese vowels compared to their correlates in Sardinian and Catalan

The following sections include formant frequency and duration data about the stressed vowels of Algh. and of each of the Sard. and mCat. varieties under investigation, in order to evaluate whether the vowels of the first system still preserve their original Cat. acoustic properties or if, on the contrary, they have visibly been adapted to the Sard. subjacent vowel system of the

majority of historic immigrants to the city. As anticipated above in § 5.6.1.2, the analysis was carried out in terms of both spectroacoustic and vowel duration comparison, and the results are included and discussed in § 6.2.1 and § 6.2.2, respectively. Additionally, in § 6.2.3, the two different measurements dealt with in § 6.2.1 and § 6.2.2 will be discussed together so as to better evaluate the overall acoustic resemblance of Algh. vowels to those of Sard. and other Cat. varieties.

6.2.1 Spectral characteristics of stressed vowels

A summary of the mean unnormalised formant frequency values of the three vowel systems under investigation (i.e. Algh., Sard. and mCat.) is given in Table 12.[194] The mean values for Majorcan, Valencian, Western Catalan and Eastern Catalan (henceforth: Maj., Val., WestCat., EastCat.) have been extracted from R&E (2006), Table 2 (bottom).

	Sard.			CLog.			Camp.			Nuor.			NLog.		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
i	349	2124	2716	344	2066	2602	351	2138	2786	345	2118	2741	355	2173	2735
e	430	1974	2530	425	1894	2475	448	1958	2518	422	2067	2636	425	1976	2493
ɛ	548	1818	2494	554	1710	2446	551	1809	2504	561	1914	2543	526	1838	2485
a	753	1345	2418	704	1333	2353	753	1346	2399	806	1374	2490	747	1325	2429
ɔ	537	1040	2409	533	1045	2292	530	1019	2459	558	1062	2384	526	1032	2499
o	433	991	2409	418	1012	2289	454	993	2488	436	999	2381	427	960	2478
u	358	929	2346	348	975	2210	369	918	2432	360	934	2305	353	892	2438

	mCat.			Maj.			Val.			WestCat.			EastCat.		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
i	327	2126	2687	328	2151	2732	322	2145	2615	323	2128	2740	334	2078	2662
e	462	1859	2589	489	1905	2656	460	1837	2575	448	1854	2552	450	1839	2571
ɛ	609	1717	2480	659	1739	2524	601	1764	2521	595	1665	2440	581	1700	2434
a	707	1414	2459	739	1464	2486	681	1419	2484	676	1415	2402	730	1358	2462
ɔ	631	1151	2398	708	1178	2525	621	1158	2445	586	1142	2240	608	1125	2382
o	502	1043	2406	547	1000	2591	493	1059	2409	477	1065	2256	489	1047	2368
u	383	931	2467	394	899	2637	370	923	2482	372	942	2317	394	960	2431

	Algh.		
	F1	F2	F3
i	348	2149	2668
e	437	2014	2597
ɛ	556	1798	2518
a	737	1354	2488
ɔ	539	1019	2509
o	446	962	2525
u	360	936	2413

Table 12: Unnormalised F1, F2, F3 frequency values for the stressed vowels of Algh. and individual Sard. and mCat. varieties. Cross-dialectal values have also been included for Sard. and mCat. Data for Maj. stressed schwa are not shown in the table.

[194] A further table containing mean formant frequency values for each participant is given in Appendix IV.

Before commenting on the formant frequency values shown in Table 12, something needs to be said about the effect of the syntactic shift on the Camp. word 'gi**o**ia', and especially on its target vowel [o]. As expected, the mean F0 of the target 'o' in 'Gi**o**ias e prendas' proved to be higher than the corresponding value in 'Prendas e gi**o**ias' (i.e., 191 Hz and 95 Hz, respectively). At the same time, the corresponding mean F1, F2 and F3 values, computed over five repetitions, were the following:

'Gi**o**ias e prendas' → F0 = 191 Hz; F1 = 464 Hz; F2 = 1061 Hz; F3 = 2637 Hz
'Prendas e gi**o**ias' → F0 = 95 Hz; F1 = 474 Hz; F2 = 1031 Hz; F3 = 2369 Hz

Even though the mean values in question were obtained across just five repetitions, and should therefore be treated merely as exploratory data, it is nonetheless possible to see two clear tendencies in the results. On the one hand, there appears to be a positive correlation between the raising of F0 and F3. On the other hand, a minor or null correlation was found between the shift of F0 and the F1 and F2 values, in accordance with the results shown in Chládková et al. (2009) for male speakers.[195] Hence, no important F1xF2 changes are expected for Camp. /o/ as a function of a higher F0 in 'Gi**o**ias e prendas', whereas higher F3 values are expected to be possibly present for the same vowel.[196]

Consistently with the remarks made in Chapter 1, the first and general acoustic comparison of Algh. vowels was carried out with the corresponding vowels in Sard. (cross-dialectally) and mCat. (cross-dialectally). The results for the F1xF2 unnormalised data have been plotted in Fig. 19.

[195] See Figs. 2 and 3 in that study. A possible problem in comparing the results of the two research works is that the two vowel realisations were only classified here as having a higher vs. lower F0, whereas in Chládková et al., 2009 there were three height categories, i.e. 'low', 'normal' and 'high'. However, this taxonomical difference seems not to have caused any confusion in the comparison of the data for the first formant, since in both studies F1 hardly changed as a function of F0 height across all the categories. With regard to F2, this formant was seen in Chládková et al. to be almost identical in the 'low' and 'normal' F0 conditions, and to raise slightly when F0 was classified as 'high'; this outcome can have, at most, minor consequences in the comparison between the authors' findings and the corresponding findings in the present work.

[196] The incidence of this F3 difference on the overall mean of Camp. /o/ should be redimensioned by the fact that it only concerns one out of the three consonantal contexts (i.e. pal.). In this respect, an F3 difference between the high and low F0 conditions in the pal. context of 268 Hz should contribute to increasing the overall F3 of /o/ across the three contexts by 89 Hz (i.e. 289 Hz/3).

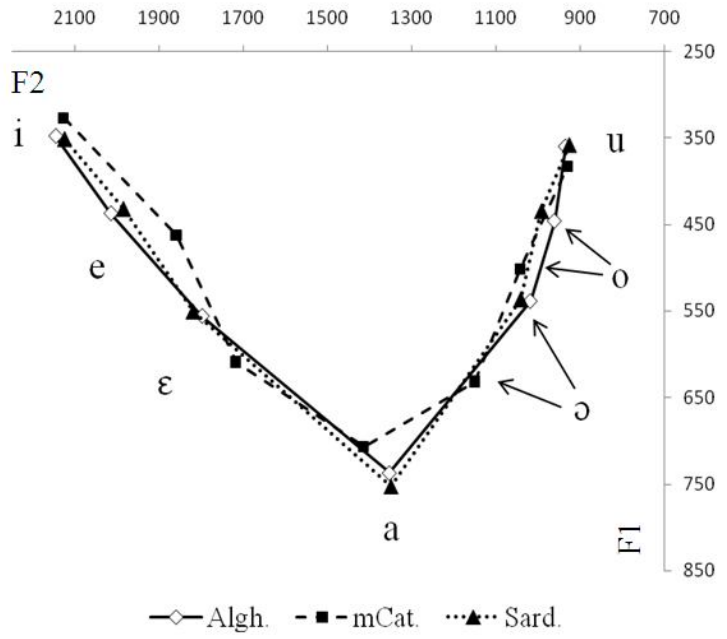


Figure 19: Mean unnormalised F1xF2 values for the vowels of Algh., Sard. (cross-dialectally) and mCat. (cross-dialectally).

According to the data shown in Table 12 and Fig. 19, it seems quite clear that the Algh. vowels do not differ from the Sard. vowels as much as they do with respect to the corresponding mCat. vowels. The maximum F1 convergence across the three systems seems to occur for the close vowels /i/ and /u/, whereas the other point vowel (/a/) is slightly higher in mCat. With regard to mid vowels, they are clearly higher in Sard. and Algh., particularly in the back area, with mCat. /o/ almost overlapping Sard. and Algh. /ɔ/.

With regard to F2, the mCat. front mid vowels /e, ɛ/ appear to be more posterior than their Algh. and Sard. counterparts. By contrast, /a/, /ɔ/ and /o/ are more backed in Algh. and Sard. than in mCat., indicating that the latter system might be less dispersed than the first two (see below § 6.3.1).

Table 13[197] and Fig. 20 show the normalised F1, F2 and F3 values for the vowels of Algh. and the individual Sard. and mCat. varieties. The cross-dialectal Sard. and mCat. formant frequency values are also given.

[197] A further table containing mean normalised formant frequency values for each participant is given in Appendix V.

	Sard.			CLog.			Camp.			Nuor.			NLog.		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
i	-0.300	0.427	0.076	-0.293	0.409	0.090	-0.311	0.439	0.032	-0.329	0.403	0.095	-0.269	0.459	0.087
e	-0.091	0.354	0.023	-0.079	0.322	0.040	-0.068	0.351	-0.001	-0.125	0.379	0.056	-0.090	0.364	-0.005
ɛ	0.152	0.271	0.018	0.183	0.219	0.028	0.140	0.271	0.031	0.159	0.302	0.020	0.125	0.291	-0.008
a	0.468	-0.030	-0.002	0.423	-0.030	-0.011	0.453	-0.024	0.034	0.521	-0.030	-0.002	0.474	-0.036	-0.031
ɔ	0.130	-0.287	-0.021	0.144	-0.273	-0.036	0.101	-0.302	-0.001	0.154	-0.288	-0.045	0.121	-0.286	-0.003
o	-0.083	-0.335	-0.030	-0.097	-0.305	-0.038	-0.054	-0.328	-0.024	-0.095	-0.350	-0.047	-0.086	-0.359	-0.012
u	-0.276	-0.400	-0.063	-0.280	-0.342	-0.073	-0.262	-0.407	-0.071	-0.285	-0.417	-0.079	-0.275	-0.432	-0.028

	mCat.			Maj.			Val.			WestCat.			EastCat.		
	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3	F1	F2	F3
i	-0.427	0.415	0.074	-0.490	0.424	0.051	-0.422	0.419	0.044	-0.397	0.401	0.127	-0.400	0.416	0.074
e	-0.081	0.282	0.037	-0.089	0.303	0.023	-0.065	0.263	0.029	-0.098	0.280	0.055	-0.072	0.280	0.041
ɛ	0.193	0.202	-0.006	0.208	0.212	-0.027	0.199	0.222	0.008	0.156	0.203	0.011	0.210	0.172	-0.015
a	0.343	0.008	-0.014	0.323	0.039	-0.042	0.327	0.006	-0.006	0.384	-0.022	-0.005	0.337	0.010	-0.004
ɔ	0.228	-0.198	-0.041	0.281	-0.178	-0.027	0.236	-0.198	-0.023	0.202	-0.210	-0.075	0.195	-0.205	-0.037
o	0.001	-0.297	-0.038	0.021	-0.342	-0.001	0.006	-0.288	-0.041	-0.015	-0.282	-0.069	-0.010	-0.274	-0.042
u	-0.270	-0.410	-0.014	-0.306	-0.448	0.016	-0.282	-0.424	-0.010	-0.231	-0.370	-0.044	-0.260	-0.399	-0.017

	Algh.		
	F1	F2	F3
i	-0.309	0.441	0.053
e	-0.081	0.376	0.027
ɛ	0.159	0.263	-0.004
a	0.439	-0.022	-0.016
ɔ	0.128	-0.304	-0.009
o	-0.060	-0.362	-0.003
u	-0.275	-0.390	-0.048

Table 13: Mean normalised (CLIH) F1, F2, F3 frequency values for the stressed vowels of Algh., Sard. and mCat., both for individual varieties and cross-dialectally. Values for Maj. stressed schwa are not shown in the table.

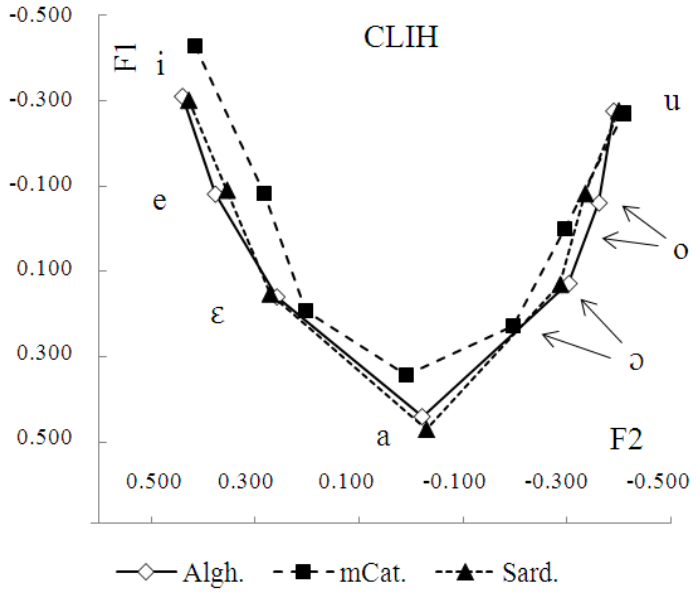


Figure 20: Mean normalised (CLIH) F1xF2 values for the vowels of Algh., Sard. and mCat.

When normalised F1 data are taken into account, the distance between Algh./Sard. and mCat. is still apparent for the back vowels /o, ɔ/, although it seems to have diminished with respect to the corresponding unnormalised data. The distance between front vowels /e, ɛ/ also seems to have decreased, although this is not the case for /a/ or, in particular, /i/, where the formant frequency gap is even greater.

Minor differences were found, on the other hand, between the unnormalised and normalised F2 data, since the slightly different shape of the two vowel diagrams shown in Fig. 19 (which plots unnormalised data) and Fig. 20 (which represents CLIH data) is mainly due to F1 differences.

Dialect/language-dependent differences in formant frequency between the Algh. vowels and the corresponding vowels in other Cat. varieties, on the one hand, and between the Algh. and Sard. vowels, on the other, were assessed by applying one-way ANOVAs to the normalised formant frequency data for each vowel with 'dialect' as the independent variable, in accordance with the procedure described in section 5.6.1.2.

ANOVAs run on the normalised frequency values of Algh. and the other Cat. varieties yielded a significant effect of 'dialect' for F1 of the vowels /i, e, a, ɔ, o/ (respectively, $F(4,70)=24.17$, $p < 0.001$; $F(4,70)=4$, $p < 0.01$; $F(4,70)=8.907$, $p < 0.001$; $F(4,70)=22.87$, $p <$

0.001; F(4,70)=4.64, $p < 0.01$), and for F2 of the vowels /i, e, ɛ, a, ɔ, o/ (F(4,70)=675.5, $p < 0.001$; F(4,70)=183.2, $p < 0.001$; F(4,70)=7.019, $p < 0.001$; F(4,70)=49.26, $p < 0.001$; F(4,70)=23.26, $p < 0.001$; F(4,70)=9.821, $p < 0.001$).

On the Sard. side, significant differences were found among Algh. and the Sard. varieties for F1 of the vowels /i, e, ɛ, a, ɔ, o/ (F(4,70)=7.49, $p < 0.001$; F(4,70)=5.49, $p < 0.001$; F(4,70)=3.87, $p < 0.01$; F(4,70)=8.11, $p < 0.001$; F(4,70)=4.38, $p < 0.01$; F(4,70)=5.21, $p < 0.001$), and for F2 of the vowels /i, e, ɛ/ F(4,70)=5.79, $p < 0.001$; F(4,70)=6.27, $p < 0.001$; F(4,70)=11.47 $p < 0.001$).

As anticipated above in § 5.6.1.2, a further investigation was carried out on the formant frequency differences between the vowels of Algh. and the corresponding vowels in the individual Sard. and mCat. varieties, both in terms of F1 and the mean Euclidean distances. The results are reported in Table 14 and Fig. 21.

mean F1 differences			
unnormalised		normalised (CLIH)	
dialect	mean diff. (Hz)	dialect	mean diff.
Algh.	0.0	Algh.	0.000
Camp.	8.6	Camp.	0.013
CLog.	13.6	CLog.	0.016
NLog.	14.0	NLog.	0.022
Nuor.	17.5	Nuor.	0.031
EastCat.	29.4	EastCat.	0.047
WestCat.	32.4	WestCat.	0.055
Val.	41.5	Val.	0.066
Maj.	68.8	Maj.	0.088

mean Euclidean differences			
unnormalised		normalised (CLIH)	
dialect	mean diff. (Hz)	dialect	mean diff.
Algh.	0.0	Algh.	0.000
Camp.	23.0	Camp.	0.021
NLog.	32.5	NLog.	0.033
Nuor.	51.6	Nuor.	0.043
CLog.	65.2	CLog.	0.044
EastCat.	88.9	EastCat.	0.081
Val.	90.5	WestCat.	0.091
WestCat.	95.8	Val.	0.098
Maj.	108.5	Maj.	0.115

Table 14: Mean F1 and Euclidean differences for the vowels of Algh. and those of the individual mCat. and Sard. varieties. Given '0' as the mean value for Algh., the other dialects have been ranked in order from the one presenting the most similar mean values to the one presenting the most distant mean values.

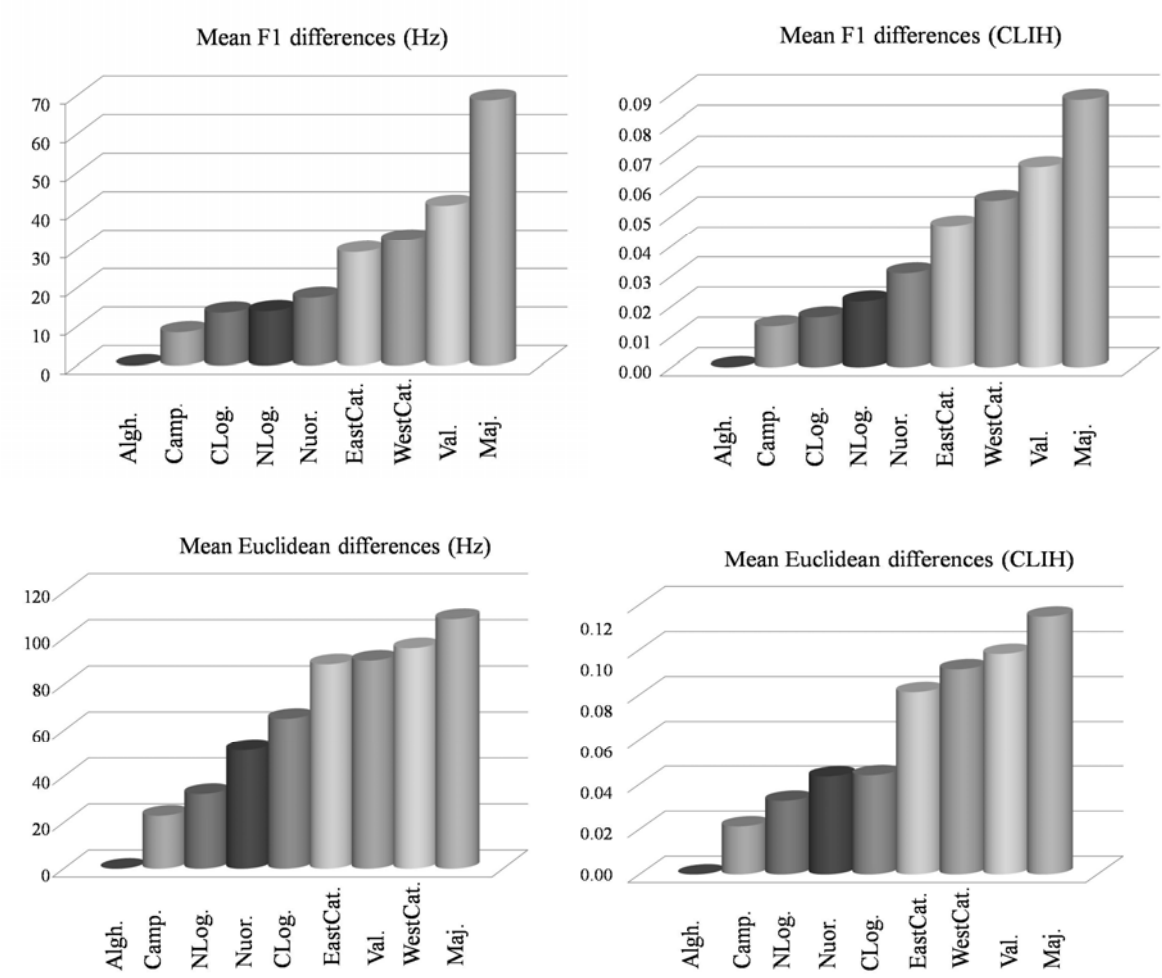


Figure 21: Mean F1 (top) and Euclidean differences (bottom) for the vowels of each variety with respect to those of Algh., ranked in order from the lowest to the highest. Data are presented both for the unnormalised (left graphs) and normalised (right graphs) frequency values.

The F1xF2 comparison (along with the vowel duration comparison dealt with in the next section) between Algh. and the individual Sard. dialects was carried out in order to verify whether the variety of reference for Algh. is, as expected from studies and historical documents dealing with repopulation processes and adstratum contacts concerning the city, the one spoken in the areas surrounding Alghero, i.e. NLog. In this respect, it is at first sight quite surprising that the closest Sard. variety to Algh. in terms of mean F1 differences turned out to be Camp., which is also the most distant variety – geographically speaking – from the city. Yet if the same results are analysed more in detail, it actually appears that all the Sard. varieties, not just Camp., present similar F1 characteristics to those of Algh., in that the mean unnormalised F1 difference between Algh. and Camp., which is 8.6 Hz, differs very little from that between Algh. and the other Sard. varieties, i.e. 13.6 Hz (CLog.), 14 Hz (NLog.)

and 17.5 Hz (Nuor.). The most 'distant' Sard. dialect from Algh. (i.e. Nuor.) in fact presents mean F1 differences which are just 8.9 Hz higher than the closest one (i.e. Camp.).

When the corresponding mean Euclidean distances are taken into account, the most similar values to Algh. can again be found in Camp. (23 Hz), whereas the most 'distant' variety turned out to be CLog. (65.2 Hz), with a ratio between the two differences of roughly 3:1. These results also indicate that considerable acoustic convergence is apparent between the stressed vowels of Camp. and Algh., but again it should not be overlooked that the second-nearest variety (i.e. NLog.) presents a mean Euclidean difference which is just 9.5 Hz higher than that of Camp. In this respect, unnormalised (top graph) and normalised (bottom graph) F1xF2 values for Algh. and the Sard. dialects are plotted in Fig. 22. The graphs show a general convergence of Algh., Camp. and NLog. vowels, while the most apparent differences are between the vowels of Algh. and the corresponding vowels of Nuor. and CLog., namely in terms of F2 shift for front vowels and /a/. More specifically, the open vowel /a/ of CLog. and Nuor. appears to be, respectively, higher and lower than the corresponding Algh. vowel. Also, in terms of F2, the front vowels of CLog. seem more posterior, and those of Nuor. more anterior, than their Algh. counterparts.

With regard to the normalised data, the F2 difference between Algh. and CLog. and Nuor. decreases in the case of front vowels (both Sard. dialects) and in the case of /o/ and /u/ as well (CLog. only).

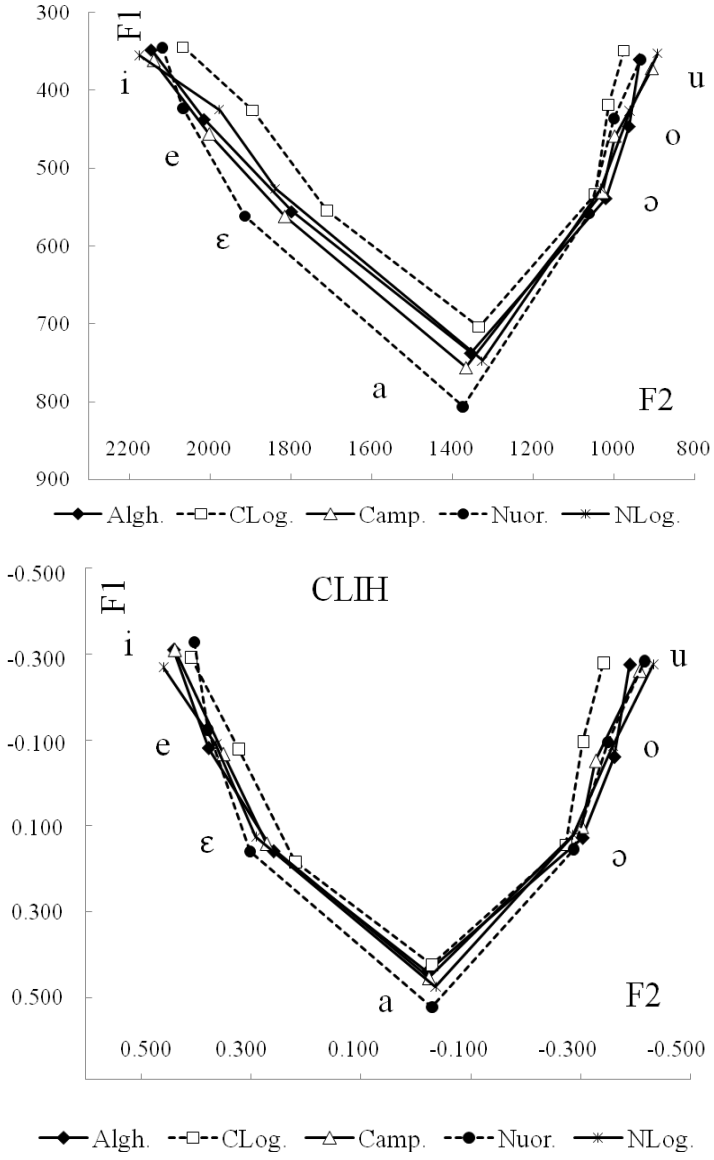


Figure 22: Unnormalised (top graph) and normalised (bottom graph) F1xF2 values for the vowels of Algh. and those of the individual Sard. varieties. The acoustically most 'distant' varieties from Algh., i.e. CLog. and Nuor., are indicated with dotted lines.

So far, mean formant data on the collocation in the vowel space of Algh. and Sard. vowels indicate a great convergence of Algh. vowels with the corresponding vowels in Camp. and NLog., while some clearer formant differences have been detected with respect to CLog. and Nuor. As mentioned in Chapter 1, the possibility that Camp.-speaking immigrants may have also contributed to the modification of the acoustic quality of Algh. vowels cannot be excluded, even though the historical records of immigration to the city available to the present researcher make this possibility less likely than might be hypothesised with respect to NLog. In this respect, as will be seen below, further analyses of our acoustic data have been carried

out to better understand whether or not the proximity between Algh. and Camp. vowels should be considered to some extent accidental.

As regards the acoustic comparison of Algh. vowels with the corresponding vowels in the other Cat. varieties, the data in Table 14 and Fig. 21 indicate that the closest formant frequency values (both in terms of F1 differences and Euclidean distances) can be found for Algh. and EastCat., i.e. the variety spoken in the cities of Barcelona and Tarragona and other areas of eastern Catalonia. It should be added, consistently with the data reported in Figs. 19 and 20, that the formant differences between Algh. and the individual mCat. varieties are greater than the corresponding differences between Algh. and the Sard. varieties. It is no surprise that the closest mCat. variety to Algh. (EastCat.) still presents higher mean F1 differences in respect of the latter (29.4 Hz and 0.047 CLIH) than the most distant Sard. correspondent (Nuor., with 17.5 Hz and 0.031 CLIH).

As already seen for the formant comparison between Algh. and the Sard. varieties, the F1 differences do not seem to indicate an 'absolutely' closest Cat. dialect to Algh., since the second and third closest varieties (WestCat. and Val., with 32.4 Hz and 41.5 Hz, respectively) presented distances that were quite similar to the closest one (EastCat., with 29.4 Hz). By contrast, a much greater acoustic distance on the height dimension seems to separate Algh. from Maj. (68.8 Hz).

Similar results have been found for the mean Euclidean distances, since the three closest dialects to Algh. (EastCat., Val. and WestCat. with, respectively, 88.9 Hz, 90.5 Hz, 95.8 Hz) were quite close to one other (maximum gap = 5.9 Hz), whereas rather higher values have been found for Maj. (108.5 Hz).

The results of the ANOVAs reported in the current section were intended to establish whether the F1 and F2 frequency values for the individual vowels of Algh., and those of mCat. and Sard., presented statistically significant differences as a function of the variable 'dialect'. The same differences were also assessed between Algh. and the individual Sard. and mCat. dialects by analysing the corresponding results of Tukey's pairwise comparisons, as shown in Table 15.

F1

Algh.	CLog.	Camp.	Nuor.	NLog.	Maj.	Val.	EastCat.	WestCat.	
				$p < 0.01$	$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	/i/
			$p < 0.01$						/e/
									/ɛ/
			$p < 0.001$		$p < 0.001$	$p < 0.001$		$p < 0.001$	/a/
					$p < 0.001$	$p < 0.001$	$p < 0.01$	$p < 0.01$	/ɔ/
	$p < 0.05$				$p < 0.001$				/o/
									/u/

F2

Algh.	CLog.	Camp.	Nuor.	NLog.	Maj.	Val.	EastCat.	WestCat.	
			$p < 0.05$		$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	/i/
	$p < 0.001$				$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	/e/
	$p < 0.05$		$p < 0.05$		$p < 0.01$	$p < 0.001$	$p < 0.01$		/ɛ/
					$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	/a/
					$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	/ɔ/
					$p < 0.001$	$p < 0.001$	$p < 0.001$	$p < 0.001$	/o/
									/u/

Table 15: Tukey's pairwise comparisons run on the formant frequency values for the vowels of Algh. and the Sard. varieties (left columns) and for the vowels of Algh. and the other Cat. varieties (right columns). The empty cells correspond to statistically non-significant differences (i.e. $p \geq 0.05$).

The table shows that the variable 'dialect' yelded more significant effects for F2 than for F1, and for the mCat. varieties than for the Sard. ones. Once again, the varieties which showed less statistically significant formant frequency differences with respect to Algh. were Camp. and NLog.

6.2.2 Duration of Catalan and Sardinian vowels

The other variable taken into account in the present study in order to quantitatively compare the vowels of Algh., Sard. and mCat. is 'vowel duration', as anticipated above in Chapter 1 and § 5.6.1.2. In this respect, Table 16 shows mean duration values for the stressed vowels of the varieties under investigation.

	/i/	/e/	/ɛ/	/a/	/ɔ/	/o/	/u/	**mean**
Algh.	114	138	149	146	133	119	117	**131**
CLog.	84	108	113	129	126	106	103	110
Camp.	133	168	178	188	200	155	161	169
Nuor.	79	151	120	159	135	120	123	127
NLog.	104	130	138	161	151	135	142	137
Sard.	100	139	137	159	153	129	132	**136**
Maj.	108	134	160	152	160	139	125	140
Val.	90	106	139	118	117	113	111	113
EastCat.	100	122	138	135	134	118	117	123
WestCat.	86	112	128	127	128	111	109	114
mCat.	96	118	141	133	135	120	115	**123**

Table 16: Mean duration values of stressed vowels in Algh., and the Sard. and mCat. varieties. Values are expressed in milliseconds.

In general terms the results for vowel duration seem to conform, for each variety under investigation, to those available in studies reporting a positive relationship between vowel duration and degree of opening (Elert, 1964; Westbury & Keating, 1980; Gálvez, 1995).

On average, Sard. vowels were found to be slightly longer (136 ms) than their mCat. correspondents (123 ms), with Algh. values being about halfway between the two (131 ms). With respect to the individual varieties, the most similar mean duration values to Algh. were those of Nuor. and NLog. (mean difference = 4 ms and 6 ms, respectively), and EastCat. and Maj. (mean difference = 8 ms and 9 ms, respectively). Greater differences in vowel duration were visible for Algh. vs. CLog. (21 ms), Camp. (38 ms) and, on the Cat. side, WestCat. (17 ms) and Val. (18 ms).

One-way ANOVAs were run on the Algh. and Sard. vowel duration values in order to test the significance of the 'intuitive' remarks made above on the higher compatibility between the Algh. data and the corresponding data for NLog. and Nuor. As anticipated in § 5.6.1.2, ANOVAs could not be run on the vowel duration data for Algh. and the other Cat. varieties because vowel duration values as a function of individual speakers and consonantal context were not available for the latter.

In general terms, the clear difference in vowel duration between the longest (i.e. Camp.) and the shortest values (i.e. CLog.) found consistency in the highly significant effect ($p < 0.001$)

of 'dialect' for all the vowels: /i/ F(4,70)=19.53, p < 0.001; /e/ F(4,70)=9.39, p < 0.001; /ɛ/ F(4,70)=9.39, p < 0.001; /a/ F(4,70)=5.73, p < 0.001; /ɔ/ F(4,70)=9.39, p < 0.001; /o/ F(4,70)=9.39, p < 0.001; /u/ F(4,70)=6.78, p < 0.001. As regards the differences between Algh. and the individual Sard. varieties, Table 17 shows the results for the Tukey's pairwise comparisons between the vowel duration values for all dialectal varieties in question.

	CLog.	Camp.	Nuor.	NLog.	
Algh.	$p < 0.01$	$p < 0.05$	$p < 0.001$		/i/
	$p < 0.05$	$p < 0.05$			/e/
	$p < 0.05$				/ɛ/
		$p < 0.001$			/a/
		$p < 0.001$			/ɔ/
		$p < 0.001$			/o/
		$p < 0.001$			/u/

Table 17: Pairwise comparisons between the Algh. and Sard. vowel duration values. The empty cells represent statistically non-significant differences (i.e. $p \geq 0.05$).

The results displayed in the table would appear to confirm the 'intuitive' consideration that the duration of Algh. vowels is more compatible with that of NLog. (there were no statistically significant differences in this case) and Nuor. (there was one vowel difference in this case) than with that of CLog. (3) and especially Camp. (6), which is in this respect by far the most distant variety from Algh. This latter fact would make quite improbable the supposition that Camp. immigrants played the most relevant role in acoustically reshaping Algh. vowels.[198]

6.2.3 Final remarks on the quality of Algherese vowels between their Catalan origin and Sardinian influence

At the end of Chapter 1, after having reviewed various historical and sociolinguistic facts concerning the repopulation of the city of Alghero, and having further dealt with different variables possibly affecting the degree of accent-free L2 acquisition by the immigrants populating the city over the centuries, it was foreseen that such factors as the possible lack of

[198] On the other hand, it could be interesting in future studies to evaluate to what extent the longer duration of Camp. vowels is an intrinsic feature of the vowels in question and how much it is due to an overall slower speech rate of Camp. speakers. In order to test this issue, some exploratory measurements (10 for each Sard. variety) were carried out on phrase number 5 of the questionnaire ('Isto in Bosa') by dividing phrase duration by the number of available phonemes. Results showed that the speech rate for Camp. speakers was in fact slightly lower than the speech rate for the other varieties (130 ms and 120 ms, respectively).

social control over non categorical vowel changes (e.g. [ɔ] → [ɔ̯]), and the constant centuries long immigration to the city by (mainly) Sard. immigrants, could have contributed to unbalancing, in favour of the latter, the conservative tendency of maintaining Cat. origin vowel characteristics vs. the innovative tendency towards acoustic changes. This hypothesis seems to be clearly supported by all the spectroacoustic comparisons, both cross-dialectally (see Tables 12 and 13 and Figs. 19 and 20 above) and for individual varieties (Tables 14 and 15 and Fig. 21).

On the other hand, a clear-cut difference between Algh., Sard. and mCat. has not been found to hold in terms of vowel duration, since the duration values for the three system vowels did not differ much in this respect. Hence, the variable 'vowel duration' cannot be said either to support or deny the hypothesis (otherwise strongly supported by the formant data) that Algh. vowels resemble their Sard. counterparts more than the corresponding mCat. vowels.

As regards the possible Sard. variety of reference for Algh., Table 18 summarises the results obtained both for the formant frequency and vowel duration comparisons between Algh. and each Sard. variety. The table also includes the corresponding results for the mCat. varieties.

	CLog.	Camp.	Nuor.	NLog.	
form. freq. values		X		X	Algh.
vowel duration			X	X	

	Maj.	Val.	WestCat.	EastCat.	
form. freq. values		X	X	X	Algh.
vowel duration	X			X	

Table 18: Summary of the Sard. and mCat. varieties presenting the highest degree of compatibility with Algh. in terms of vowel formant frequency and vowel duration. The Sard. and mCat. dialects showing the highest degree of compatibility are marked with ellipses.

The Sard. variety that presents the most compatible formant frequency and vowel duration values is NLog., as predicted at the end of Chapter 1. On the Cat. side, the most compatible variety is EastCat. It is probably useful to remember here that the similarity of the two varieties (NLog. and EastCat.) to Algh. should be considered from two rather different perspectives. According to Table 14 and Fig. 21 above, NLog., along with Camp., was found to present the most similar vowels to Algh. of *all* the varieties (both Sard. and mCat.) under investigation, whereas EastCat. has to be considered the closest among mCat. varieties *only*.

The difference is not irrelevant, since the F1xF2 mean values for the Algh. vowels still resemble much more closely those of the most distant Sard. variety (i.e. Nuor. with regard to mean F1 differences and CLog. for mean Euclidean differences) than those of the closest mCat. variety (i.e. EastCat., in terms of both mean F1 and Euclidean differences).

The finding, on the Cat. side, that EastCat. presents the highest degree of similarity to Algh. in terms of both spectroacoustic values and vowel duration is quite interesting, since the documents and the literature dealt with in Chapter 1 did not allow any reliable prediction of which Cat. variety could be expected to be most similar, in terms of vowel quality, to Algh. This convergence can be interpreted *a posteriori* as the possible effect of the adstratum contact between the city of Alghero and some Cat. port cities (particularly Barcelona) even long after political connections ceased in 1720. However, this 'romantic' hypothesis is put into perspective by the fact that archive documents provide evidence of trade between the port of Alghero and the ports of Barcelona and Valencia (Caria, 1995:120), which are areas where two different varieties of Cat. are spoken. This hypothesis is further weakened by the fact that in the last two centuries trade between Alghero and other Catalan speaking cities has decreased constantly, with the result that their diastratic influence on Algh. should be considered far inferior to, for example, the possible influence of Neapolitan and Genoese seamen and immigrants (among others). In other words, the higher compatibility between Algh. and EastCat. is not interpreted here as the result of a prolonged direct influence of the latter variety on Algh., and it is more prudent to attribute it to the accidental fact that EastCat. is the Cat. variety showing the lowest vowel formant frequency and duration distances in comparison to NLog. and, consequently, to Algh.

Some possible problems in evaluating the research hypothesis relating to the first aim of the present work were introduced in the commentaries on Fig. 7 above (§ 1.3). For example, the possibility that two given vowel inventories might present more or less 'accidental' similarities in terms of formant frequency values was not excluded – a possibility which would have nothing to do with the hypothesis tested in the present work, namely that Algh. vowels are the result of sociolinguistic and repopulation-related facts regarding the history of the city, or, by contrast, the result of 'acoustic' fidelity to Catalan origin vowels. In this respect, the fact that the formant frequency distances between Algh. and mCat. are visibly greater than those between Algh. and Sard. greatly aids the interpretation of the results. Also

helpful, on the Sard. side, is the fact that Camp. vowels present a very high formant frequency compatibility with the corresponding Algh. values and, at the same time, completely different duration values. The latter finding does not exclude the possibility that Camp. immigrants to the city played a role in modifying Algh. vowels, but, at the same time, there is no doubt that the vowel system of the Camp. variety did not play a primary role in this modification, since, if this was the case, its influence would also have been seen in terms of longer vowel durations in Algh. Hence, the great formant frequency compatibility between Camp. and Algh. vowels may be attributed to a considerable degree of spectral convergence between Camp. and NLog., and consequently between Camp. and Algh.

In sum, the experimental data discussed in § 6.2.1, § 6.2.2 and § 6.2.3 support the hypothesis that the phonetic characteristics of the phonological vowel system of the Algh. newcomers, who were mainly Sardinians, contributed to the spectral shift of the original Cat. vowels to the Sardinian-like ones. Another fact which supports this possibility is that the Sard. variety which was expected to have played a preeminent role in this process, i.e. NLog., was found to show highly compatible vowels to Algh., in terms of both vowel duration and formant frequency. Nonetheless, there is no doubt that the Algh. vowel system still maintains a clear Catalan phonological structure (although with some specific characteristics with respect to the other Catalan varieties). In other words, *the Algherese vowel system can be considered phonologically Catalan and phonetically Sardinian.*

6.3 Testing two ADT predictions against the Sardinian and Algherese data

The first prediction of ADT which will be tested here claims that larger inventories should occupy a larger vowel space. The data gathered for testing this possibility will be presented and discussed in § 6.3.1.

The second ADT prediction dealt with in the present work claims that vowels belonging to larger inventories are less variable. This possibility will be discussed in § 6.3.2.1 and § 6.3.2.2. In the same sections, the possibility will be also taken into consideration that contextual variability is also affected by other factors, such as the place of articulation of flanking consonants.

In § 6.3.3 the findings of §§ 6.3.1–6.3.2.2 will be discussed in both phonological and articulatory terms.

6.3.1 Positive relationship between vowel inventory size and vowel space dispersion

In order to test the ADT prediction of greater dispersion for more crowded inventories, the formant data shown in Tables 12 and 13 above were used to compute the areas encompassed by the point vowels /i, u, a/, as anticipated above in § 5.6.1.3. According to a strict version of ADT, the Algh. and Camp. systems should exhibit greater dispersion than CLog., Nuor., and NLog., since the former two possess seven contrastive vowels, whereas the latter three only possess five. In this respect, Table 19 shows the values in Hz^2 for the point-vowel areas of each variety (left column) and the corresponding values for the normalised data (right columns). The same results are also presented graphically in Fig. 23.

	Point-vowel area	
	Unnormalised	Normalised
Algh. (7)	231	0.303
CLog. (5)	195	0.266
Camp. (7)	238	0.312
Nuor. (5)	267	0.339
NLog. (5)	252	0.332

Table 19: Point-vowel area values for Algh. and the Sard. varieties. Data are given separately for the unnormalised (left column, in 1,000 Hz^2) and normalised (right column, in CLIH) formant frequencies. The number of contrastive vowels for each variety is indicated in brackets.

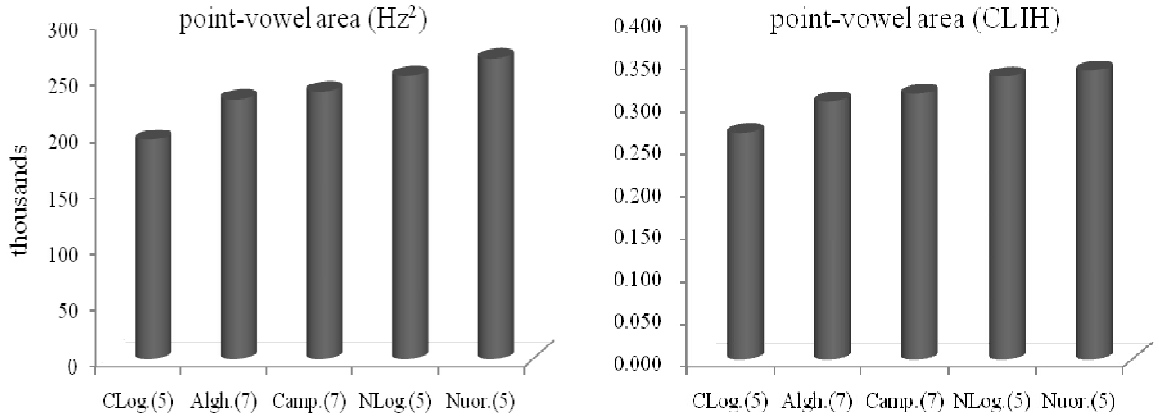


Figure 23: Point-vowel area values for Algh. and the Sard. varieties. Data are given for the unnormalised (left) and normalised (right) formant frequencies ranked from lowest to highest.

As can be seen in Fig. 23, and consistently with the results in Contini (1987:449) discussed in § 2.4 above, no general positive correlation has been found in the varieties under investigation between vowel inventory size and vowel dispersion. In fact, vowel inventories presenting the

same number of contrastive vowels, such as the Log. varieties, simultaneously exhibit the highest (Nuor. and NLog.) and lowest (CLog.) dispersion values. Similarly, the more crowded systems (Camp. and Algh.) show dispersion values which are both higher and lower than the less crowded systems. In this respect, similar outcomes have been found for both the unnormalised (left graph) and the normalised data (right graph).

Consistently with the remarks made in § 2.5, consideration is also given to the possibility of evaluating the inventory size of the Sard. varieties using a different approach from the strictly contrastive-based model. For example, a more etymologically based approach (e.g. that advocated by Bolognesi, 1998/2012) would claim that Camp. only possesses five vowel phonemes, similarly to the Log. varieties. From a different perspective, it has also been seen that vowel allophones in all the Sard. varieties tend to gather towards seven distinct areas in the vowel space, roughly corresponding to those of such heptaphonemic varieties as Algh. and other Cat. varieties. It could consequently be argued that the Sard. dialects should in fact be considered more similar to heptaphonemic than to pentaphonemic inventories.

What would happen if the ADT prediction of vowel variability is tested in accordance with the five- vs. seven-phoneme approach? A first answer is already provided by Fig. 23 above, in that the five-phoneme approach for the Sard. varieties would imply that Algh. is the most dispersed system, whereas the seven-phoneme approach would predict that all the varieties under investigation present similar degrees of expansion. Contrary to expectations, however, neither condition is shown by the graph.

Vowel space dispersion for the Sard. varieties has also been computed by averaging the mean Euclidean distances for each vowel produced in each of the three consonantal contexts (21 distances). In this case, the seven vowels of the Sard. varieties were included (i.e. /i/, [e], /ɛ/, /a/, /ɔ/, [o], /u/ of the Log. varieties, and /i/, /e/, /ɛ/, /a/, /ɔ/, /o/, /u/ of Camp.), so as to verify the hypothesis stated in section 2.5. that the Camp. vowel system expanded at a given T2 moment of its history on the basis of the new contrast between /ɛ/ and /e/ and between /ɔ/ and /o/. Following ADT, the issue to be dealt with was whether the creation of a limited number of minimal pairs in Camp. by increasing the number of contrastive vowels from five to seven also increased the need to maintain perceptual contrast – and hence vowel dispersion – with respect to the other Sard. varieties. The results of overall space dispersion are given in Table 20.

	Mean Euclidean distance	
	Unnormalised	Normalised
CLog. (5)	421	0.376
Camp. (7)	471	0.398
Nuor. (5)	499	0.426
NLog. (5)	491	0.414

Table 20: Mean Euclidean distances for the unnormalised (left column, in Hz) and normalised (right column, CLIH) formant frequency data in the four Sard. varieties. The number of contrastive vowels for each variety is indicated in brackets.

According to the ADT prediction in question, Camp. should present the highest vowel space expansion, whereas the results displayed in the table indicate that the most dispersed dialect is Nuor., which is pentaphonemic. If it is true that vowel dispersion does not directly depend on vowel inventory size across the Sard. varieties, it also becomes more and more improbable that Camp. expanded its vowel space in a given moment of its history as a function of the new contrastive relationship between /e/ and /ɛ/, and /o/ and /ɔ/.

Table 21 and Fig. 24 display the point-vowel areas for Algh. and the Sard. varieties, with the addition of the corresponding values computed for the mCat. varieties on the basis of the results reported in R&E (2006:655–656). This further comparison allows testing the ADT prediction in question against a larger number of dialects/languages, while also permitting more inter-dialectal comparisons in terms of inventory size since mCat. includes a variety (Maj.) with eight vowel phonemes, as indicated by the numbers in brackets.

	Point-vowel area	
	Unnormalised	Normalised
Algh. (7)	231	0.303
CLog. (5)	195	0.266
Camp. (7)	238	0.312
Nuor. (5)	267	0.339
NLog. (5)	252	0.332
Sard.	237	0.312
Maj. (8)	235	0.319
Val. (7)	202	0.287
EastCat. (7)	199	0.266
WestCat. (7)	192	0.272
mCat.	207	0.286

Table 21: Point-vowel area values for Algh. and the Sard. and mCat. varieties. Data are given for the unnormalised (left column, in 1,000 Hz^2) and normalised (right, in CLIH) formant frequencies. Cross-dialectal values are also reported for Sard. and mCat. The number of contrastive vowels for each variety is indicated in brackets.

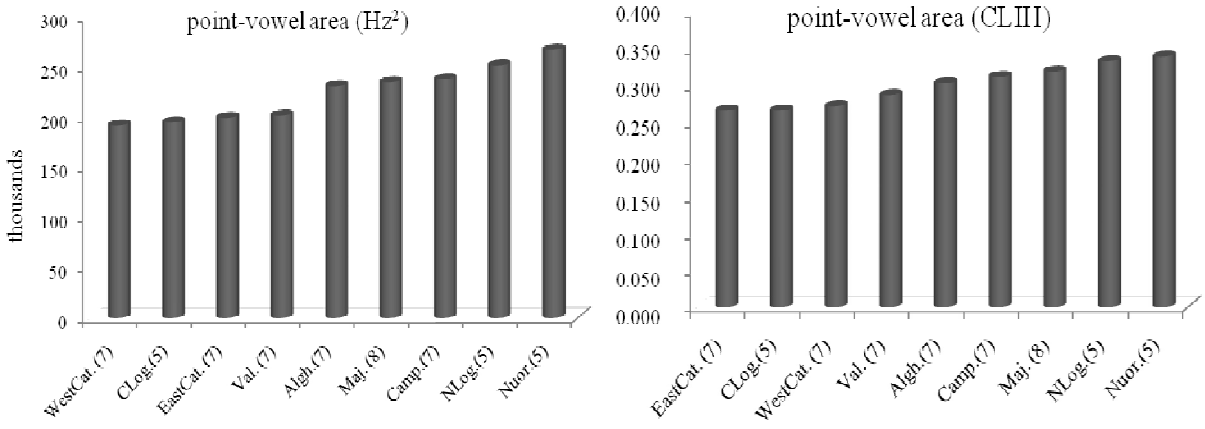


Figure 24: Point-vowel area values for Algh. and the individual Sard. and mCat. varieties, ranked in order from lowest to highest. Data are given for the unnormalised (left graph) and normalised (right graph) formant frequencies.

The point-vowel area comparison shown in the two graphs indicates that Maj. (which has the largest inventory) possesses one of the largest vowel spaces of the nine varieties under investigation, in partial accordance with the first ADT prediction. However, other information available in the graph, such as the unpredicted highest expansion for less crowded inventories (i.e. NLog. and Nuor.) and the lowest expansion for more crowded ones (i.e. WestCat. for the

unnormalised data and EastCat. for the normalised data) would appear to challenge this ADT prediction.

In sum, these results are consistent with the view that larger vowel inventories do not necessarily lead to larger vowel spaces (Bradlow, 1995; Gendrot & Adda-Decker 2005; Recasens & Espinosa, 2006). In this respect, the data provided by Livijn (2000) do not exclude the possibility that such a correlation may hold good for inventories of eight vowels and more. Our data did not allow the extensive testing of this possibility, since the majority of the varieties under investigation possessed five and seven phonemes. In the only case in which an octaphonemic inventory (Maj.) was included in the comparison, it did not exhibit the largest vowel space.

6.3.2 Inverse relationship between vowel inventory size and vowel variability

As anticipated above in § 2.2, the second prediction of the Adaptive Dispersion Theory dealt with in the present dissertation concerns another possible strategy aimed at preserving distinctiveness among contrastive vowels, i.e. a higher degree of control over articulatory changes in vowel production in more crowded vowel systems (Lindblom, 1986:33). This hypothesis was consistent with the findings of Manuel & Krakow (1984) and Manuel (1990), in that a lower degree of coarticulation was found for languages presenting richer vowel systems. In this respect, the questionnaires used in the present work allowed the researcher to isolate the coarticulatory effects on target vowels exerted by the three different consonantal contexts, providing a good corpus to test whether the variable 'vowel system size' systematically affects the degree of coarticulation in the manner predicted by Lindblom and Manuel & Krakow (i.e. the larger the inventory, the lower the variability). This hypothesis will be tested in the next section, whereas § 6.3.2.2 will deal with other variables possibly affecting the degree of context-dependent variability. Some general conclusions on the issue, along with a possible explanation of the results, will be presented in § 6.3.3. and 6.3.4.

6.3.2.1 Context-dependent variability as a function of vowel inventory size

Context-dependent variability was computed over mean contextual values for each variety and across varieties. Mean formant data for each vowel in each consonantal context (i.e. lab., dent., pal.) were calculated by averaging formant frequency values across repetitions and

speakers for the individual varieties. The results for the contextual F1 and F2 unnormalised data are reported in Table 22.

	Algh.						CLog.					
	F1			F2			F1			F2		
	lab.	dent.	pal.	lab.	dent.	pal.	lab.	dent.	pal.	lab.	dent.	pal.
i	347	343	353	2141	2181	2113	346	346	340	1988	2118	2092
e	439	432	440	1985	2020	2038	422	428	427	1892	1928	1861
ɛ	563	549	555	1775	1825	1793	558	573	532	1703	1671	1755
a	755	748	709	1264	1397	1400	704	706	701	1262	1353	1385
ɔ	534	547	535	948	1039	1071	528	543	528	1012	1024	1100
o	441	451	447	856	1011	1019	413	419	422	933	1008	1096
u	350	360	370	806	948	1053	348	346	352	870	921	1133

	Camp.						Nuor.					
	F1			F2			F1			F2		
	lab.	dent.	pal.	lab.	dent.	pal.	lab.	dent.	pal.	lab.	dent.	pal.
i	353	354	348	2127	2159	2128	350	341	343	2104	2163	2087
e	443	450	449	1971	1992	1910	420	416	431	2041	2115	2044
ɛ	556	564	534	1840	1804	1781	559	578	547	1917	1900	1924
a	743	756	760	1292	1337	1409	783	820	816	1290	1402	1429
ɔ	520	533	537	976	1040	1042	551	556	567	1024	1065	1097
o	451	441	473	933	968	1095	431	433	443	939	1012	1045
u	370	373	376	893	931	935	364	357	360	877	924	1000

	NLog.					
	F1			F2		
	lab.	dent.	pal.	lab.	dent.	pal.
i	356	355	355	2149	2215	2156
e	422	429	423	1999	1999	1930
ɛ	534	541	504	1847	1817	1850
a	742	752	746	1285	1339	1351
ɔ	517	538	522	983	1034	1080
o	423	427	430	922	964	994
u	348	356	354	853	891	931

Table 22: Mean unnormalised F1xF2 frequency values for the vowels of Algh. and the individual Sard. varieties as a function of consonantal context.

Standard deviations were computed on the contextual means shown in Table 22 so as to assess context-dependent variability for individual dialects. The results, displayed in Table 23, contain standard deviations calculated over mean formant frequency values across repetitions, speakers and the five dialects under investigation (i.e. Algh. and the four Sard. varieties). The same results are also presented graphically in Fig. 25.

	Algh.		CLog.		Camp.		Nuor.		NLog.		5 varieties (Algh.+Sard.)	
	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
i	5	41	3	69	3	18	4	40	1	36	5	41
e	4	27	21	33	25	43	8	42	4	40	4	27
ɛ	7	25	21	42	16	30	16	12	20	18	7	25
a	25	78	2	64	9	59	20	73	5	35	25	78
ɔ	8	64	9	48	9	38	8	37	11	49	8	64
o	5	92	5	81	19	90	6	54	3	36	5	92
u	10	124	3	140	7	34	4	62	4	39	10	124

Table 23: Standard deviations computed across mean contextual values of each vowel, both for individual dialects and across dialects.

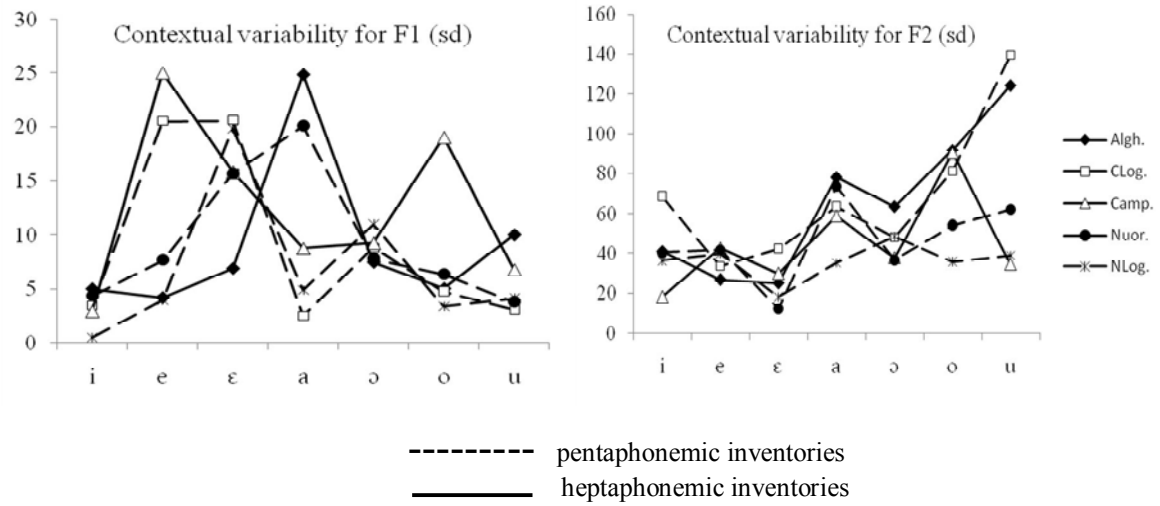


Figure 25: Graphic representation of F1 and F2 standard deviations (sd) for the vowels of the individual dialects taken from Table 23. Solid and broken lines have been used to indicate sd values for the vowels of seven- and five-vowel inventories respectively, as defined by the traditional contrastive-based approach.

The above figure aims to differentiate individual varieties as a function of inventory size. The varieties presenting seven contrastive vowels (Algh. and Camp.) are marked with solid lines, and those presenting five contrastive vowels (CLog., Nuor., and NLog.) are marked with broken lines.

According to ADT, the two varieties presenting more crowded inventories should exhibit less vowel variability than those possessing fewer vowel phonemes; consequently, in Fig. 25 the solid lines were expected to run below the broken lines. In fact, however, the variability

pattern drawn by the solid and broken lines is rather confusing, and can be read in opposite ways. On the one hand, the lowest standard deviation values for F1 of /e/, /ɛ/ and /ɔ/, and for F2 of /e/, /ɔ/ and /u/ are reached by a solid line, in accordance with the ADT prediction in question, although sometimes in tandem with a broken line. On the other hand, the solid lines may also reach the highest variability in the case of the F1 frequency values for /e/, /a/ and /o/ and of the F2 frequency values for /e/, /a/, /ɔ/ and /o/, which is contrary to the ADT prediction.

The ADT prediction for vowel variability seems to be disproved even if alternative interpretations of the term 'vowel system size' are taken into consideration, such as the five- and seven-phoneme approach for the Sard. varieties described in the previous section and in § 2.5. In fact, according to the more etymologically-based approach, which claims that Camp. only possesses five vowel phonemes, the standard deviations for Algh. (indicated in Fig. 25 by filled diamonds) should be lower than the corresponding values in all the Sard. varieties, whereas this only appears to happen accidentally, i.e. for /e, ɛ, ɔ/ on the F1 dimension and for /e/ on the corresponding F2 dimension, and not as a general rule.

As regards the seven-phoneme approach, claiming that all the Sard. varieties possess important characteristics of heptaphonemic inventories, at first sight the results displayed in Fig. 25 do not seem to challenge the ADT prediction in question since all the varieties under investigation could be said to present the same number of vowels and, at the same time, none of them seems to clearly be more (or less) dispersed than the others. A weak point of this interpretation, however, would be that major differences in variability are visible between individual varieties. To mention just one example, if the variability of /a/ is claimed to depend on the need to maintain phonemic contrast in a given inventory, it remains unexplained why, in our results, the same vowel exhibits a much higher degree of F1 variability in Algh. and Nuor. than in CLog., Camp. and NLog.

A confirmation of the finding that equally crowded inventories can exhibit different degrees of contextual variability is further provided by Fig. 26. Mean unnormalised F1xF2 contextual values for CLog. and NLog., extracted from Table 22 above, are plotted in the graphs.

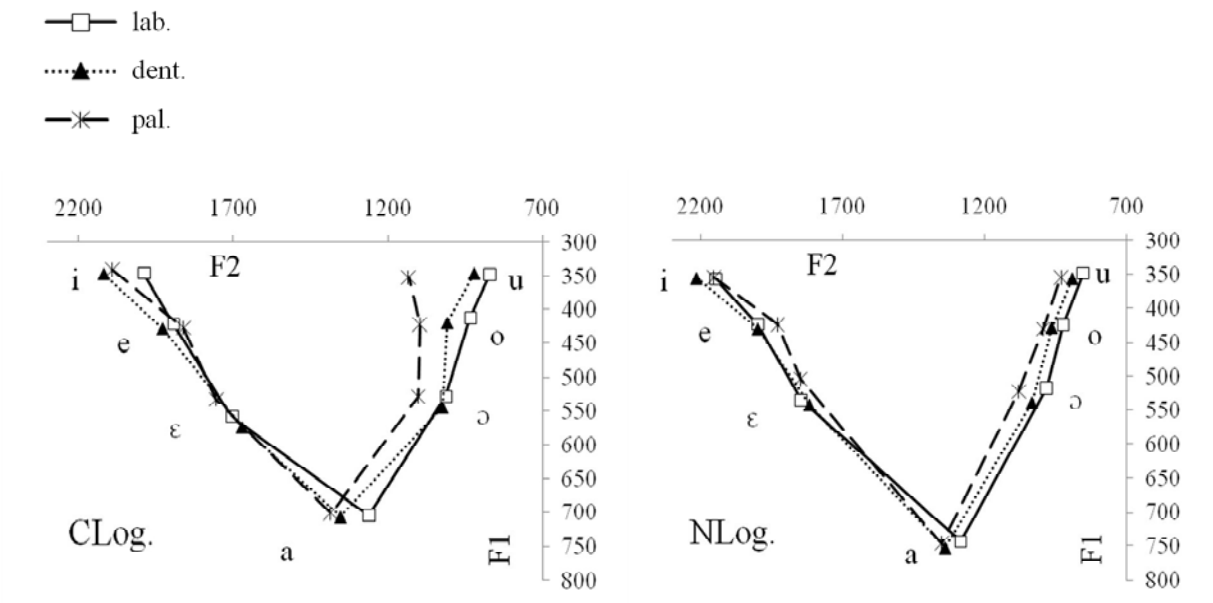


Figure 26: Contextual F1xF2 frequency values for two equally crowded vowel inventories (CLog. and NLog).

As shown in the two graphs, differences in context-dependent variation between the two equally crowded varieties can be detected, particularly for /i/, /a/ and back vowels, in that the vowels of CLog. show, in general, more context-dependent variability than those of NLog. More importantly, these differences are found in two systems presenting the same inventory size, independently of the criterion used to define vowel inventory size.

So far, no clear positive correlation has been found to hold between vowel variability and inventory size, contrary to the prediction of ADT and in accordance with the findings in R&E (2006, 2009). In the following section the degree of articulatory resistance for vowels will be further analysed as a function of other variables.

6.3.2.2 Context-dependent variability as a function of other factors: direction of formant frequency shift, language/dialect, vowel quality and place of articulation of adjacent consonants

The data discussed in the previous section appeared not to confirm the hypothesis that larger inventories possess less variable vowels. From a different perspective, Fig. 25 suggested that the degree of contextual variability might depend, to a certain extent, on such variables as ‘direction of formant shifts’ and ‘vowel quality’, in that higher standard deviations were found for horizontal F2 frequency displacements, in particular in the case of back vowels and

/a/. Moreover, Fig. 26 indicates that the variable 'language/dialect' itself, tested against equally crowded inventories, can play a role in determining the degree of contextual variability. In this respect, Fig. 27 shows the dispersion ellipses for the vowels of the varieties under investigation. The aim of the figure is to provide a general overview of coarticulatory effects in terms of the direction of F1 and F2 shifts as a function of vowel quality and language/variety.

Similarly to what is shown in Fig. 26, the dispersion ellipses of Fig. 27 suggest that the degree of contextual variability might also depend on the individual vowel taken into account, since, as a general rule, back vowels and /a/ are less resistant to coarticulatory effects than their front counterparts (the vowel quality effects will be further discussed in the commentary on Fig. 30 below). Also, the degree of variability seems to vary as a function of the direction of formant frequency displacement, given that formant shifts are seen to be more apparent along the horizontal dimension than along the vertical dimension.

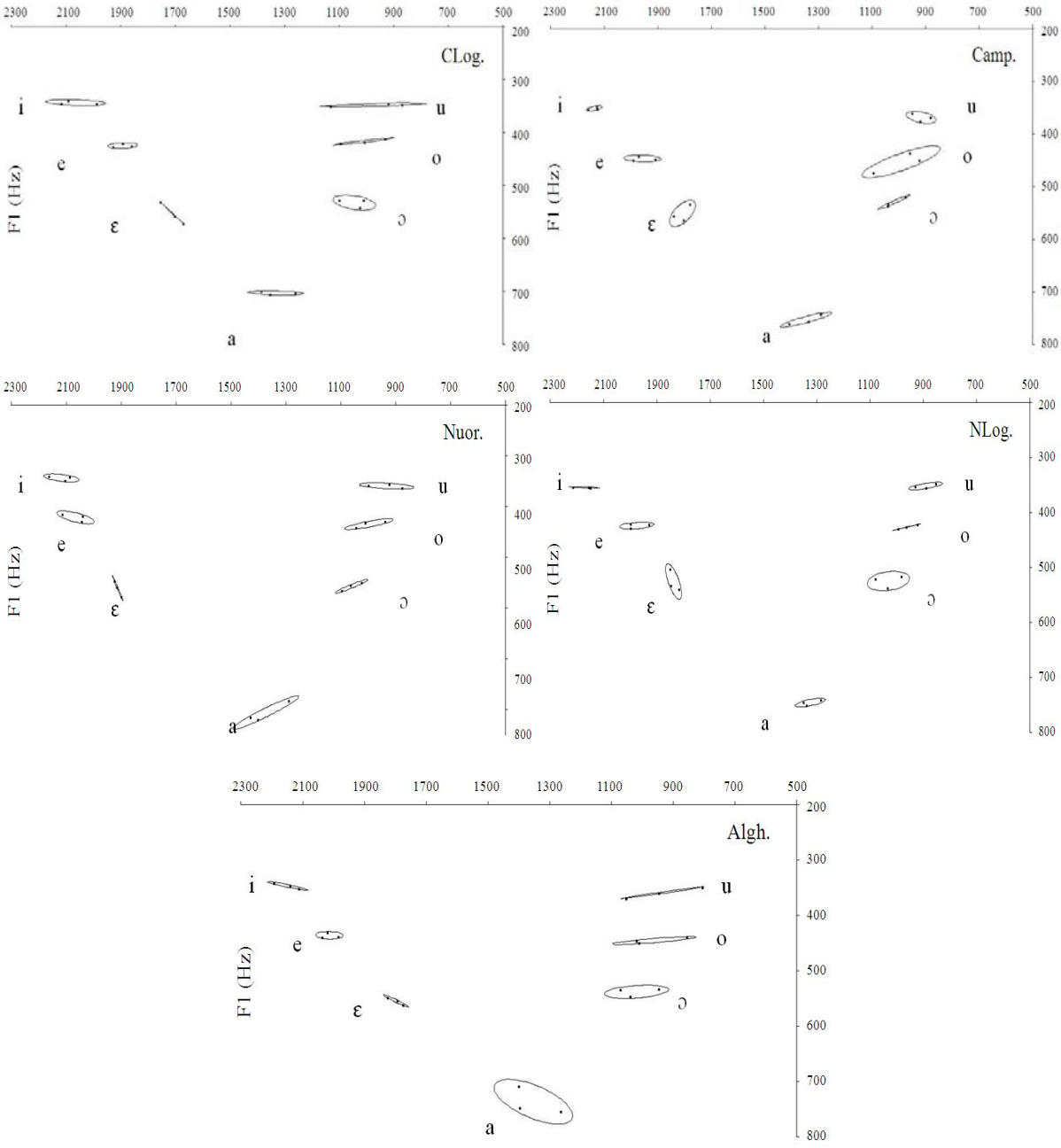


Figure 27: Contextual F1xF2 variability for the individual vowels of Algh. and the Sard. varieties. The ellipses include the mean contextual values and have the radii of two standard deviations.

With regard to the role played by the variable 'language/dialect' in determining the extent of context-dependent variability, it seems quite clear that individual vowels can undergo different degrees of variation according to dialect, though difficulties can emerge when trying to find predictors of such variability. For example, the equally crowded inventories of Algh. and Camp. exhibit vowels which are more variable in the progression Algh.>Camp. (i.e. /a/) and also in the opposite progression Camp.>Algh. (i.e. /ɛ/). For this reason, this and other

possible examples visible in Fig. 27 will be taken to reflect differences in degree of phonetic variability among languages/language varieties. Further information in this regard can be gathered from Fig. 28, in which mean unnormalised F1xF2 data as a function of consonantal context are shown for Algh. and for Sard. and mCat.

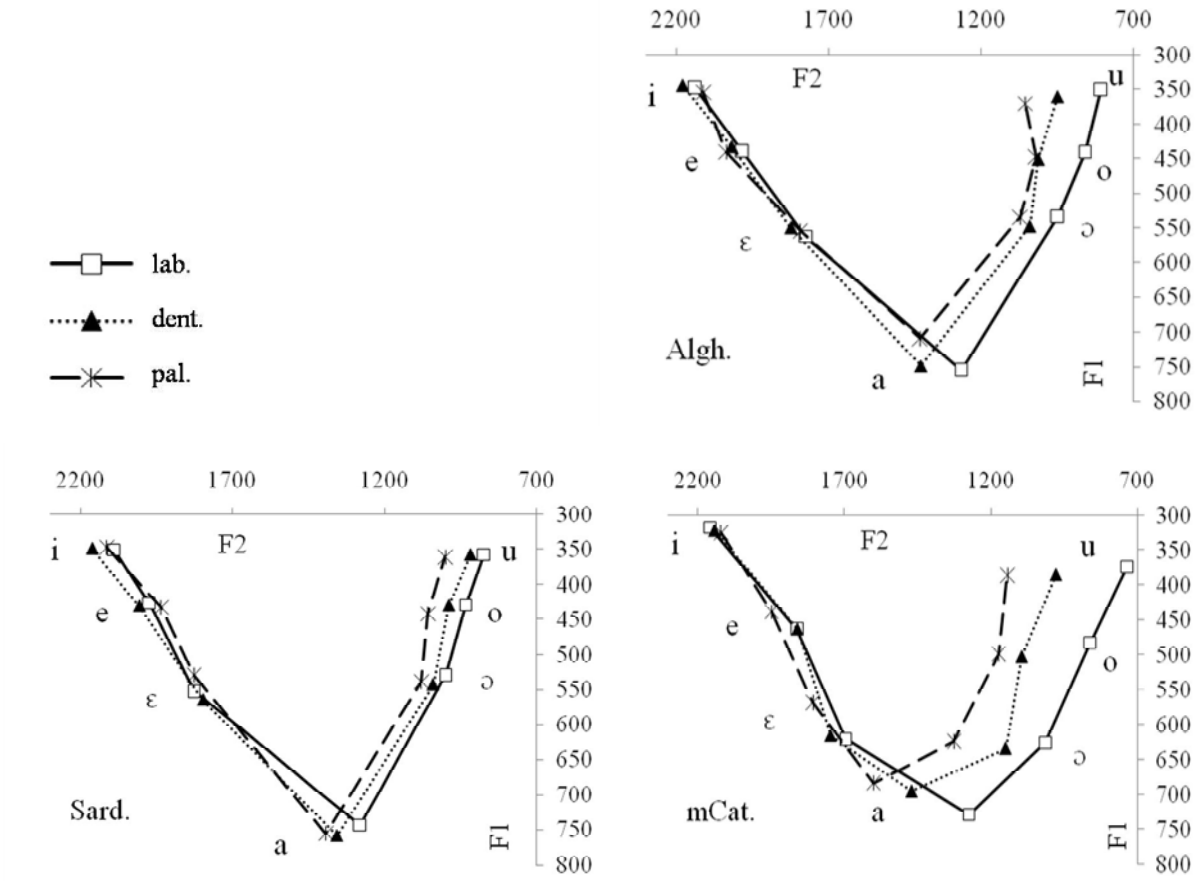


Figure 28: Contextual effects on the unnormalised F1xF2 frequency data for the vowels of Algherese, Sardinian and Catalan. The values for mCat. were adapted from R&E (2006), Fig. 7 (bottom), with the exclusion of the /l, r/ context so as to allow a perfectly symmetrical comparison among the three systems in question.

The mean contextual formant frequency values in the figure indicate at least two facts worth mentioning. First, it appears to be confirmed that language-dependent factors play a role in determining the degree of CVC variability, although this does not necessarily happen in the direction predicted by ADT. In fact, Sard. vowels are clearly less variable than the corresponding vowels in mCat., even though the varieties of the former language normally possess fewer contrasting vowels than those of the latter. Secondly, it seems that the relatively random variability attributable to different languages/varieties hypothesised a few lines earlier can be accounted for by differences in the degree of context-dependent variation across

languages, whereas the direction of this same variation appears to be particularly conditioned by consonantal context, at least for some specific vowels.

The latter consideration serves to introduce another variable which seems to affect C-to-V coarticulatory variability, namely, place of articulation of the adjacent consonants. In this respect, some information is already available in Fig. 26 above. The primary purpose of the graph is to show the different degrees of contextual variability between equally crowded systems – CLog. and NLog. – but, at the same time, it is clear that some vowels present similar patterns of context-dependent variability as a function of place of articulation for the flanking consonants. In fact, in both systems back vowels and /a/ were produced as more fronted in the dent. and, in particular, pal. contexts than in the lab. context. These results are found to be consistent with the corresponding results in Fig. 28, showing the cross-dialectal values for mCat. and Sard., and also for Algh. In fact, the F1xF2 values plotted in all three graphs of Fig. 28 would confirm that the difference in place of articulation for the flanking consonants exerts similar types of coarticulatory pressure across the three systems. More specifically, back vowels and /a/ present a clearer shift along the horizontal dimension than front vowels, with the dent. and especially the pal. environment causing /u, o, ɔ, a/ to be more anterior than the lab. context. On the vertical dimension, formant frequency shifts from the ideal vowel target have not always been implemented in the same direction across the three systems, although some cross-language tendencies can be found. As a general rule, front vowels flanked by pal. consonants have more chance of being pronounced higher than in the lab. and dent. correspondents, as is the case of /e/ (mCat.), /ɛ/ (Sard., mCat.) and /a/ (Algh., mCat.), whereas this does not appear to normally happen for back vowels, which instead exhibit slightly higher values when they are embedded in the lab. context in all three systems.

With regard to the variable 'vowel quality', it has been hypothesised throughout the present section that some vowels may present more coarticulatory resistance than others. In this respect, Fig. 29 is specifically aimed at evaluating this possibility. The standard deviations reported in the graph have been computed over mean formant frequency values across repetitions, speakers and dialects (i.e. Algh. and the Sard. varieties).

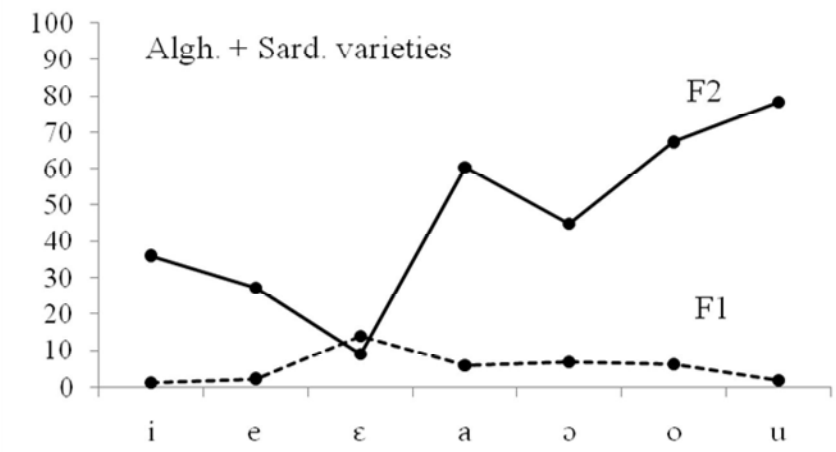


Figure 29: Standard deviations of mean F1 and F2 frequency values for the vowels of Algh. and those of the four Sard. varieties averaged across consonant contexts.

The data shown in the graph confirm that a higher degree of variability for back vs. front vowels can be found on the horizontal (F2) dimension, in the progression /u/>/o/>/a/>/ɔ/. Also, for both the back and front series, the close vowels /i/ and /u/ prove to be more variable than their close-mid and open-mid correspondents /e, ɛ/ and /o, ɔ/, respectively. In terms of F1 shift, close vowels exhibit the opposite behaviour, with /i/ and /u/ being more resistant to coarticulatory variation than mid vowels (particularly /ɛ/) and /a/.

6.3.3 Phonologically-based and articulation-based approaches to context-dependent variability

The data presented and discussed in the previous sections seem to disconfirm the two predictions of ADT tested in the present work, in that it is evident that the differences in variability across languages/dialects are not necessarily dependent on the number of contrastive vowels.

Similar context-dependent variability patterns were, on the other hand, detected among Cat. and Sard. varieties as a function of other variables, such as the direction of formant shifts (i.e. greater formant shifts were seen to happen along the fronting dimension) and vowel quality (i.e. the more articulatory-resistant vowels were seen to normally be those of the front series). A possible explanation of these findings is provided in the paragraphs that follow.

In general terms, it is believed here that the higher contextual frequency variability for back vowels and /a/, particularly along the fronting dimension, can be explained in articulatory terms; nonetheless, the possibility that phonological factors could also play a role in shaping the patterns of coarticulatory pressure should not be excluded.

From a phonological point of view, a certain degree of coarticulation on the fronting dimension in Algh. and the Sard. varieties would not greatly increase the risk of confusion among contrastive vowels, since those systems do not present any peripheral vs. non-peripheral vowel opposition.[199] For example, the average F2 distance between the more retracted and the more advanced context-dependent realisation of /u/ (i.e. in the lab. and pal. contexts, respectively) in Algh. was 247 Hz (see Table 22). The size of this horizontal gap can be explained in theory by the fact that in the same (F2) dimension there is no chance of /u/ being confused with /i/. At the same time, an equally great coarticulatory effect would surely cause confusion on the F1 axis among the front vowels /i, e, ɛ/ and also among the back vowels /ɔ, o, u/. Hence, it could be hypothesised that the need to preserve phonological distinctiveness – which is nonetheless a fundamental postulate of ADT – might be the reason why the front and back vowels of Algh. normally present a much lighter coarticulatory effect on the vertical dimension[200] than is seen for /u/ on the horizontal dimension.

The main limit of the phonologically-based approach, as it is proposed here, is that while it would account for the larger horizontal vs. vertical shifts, no possible explanation is provided for, for example, the greater shifts undergone by back vowels and /a/ vs. front vowels. Additionally, it still remains unclear why the lower risk of vowels being confused along the horizontal dimension does not simply cause random contextual variability, whereas Figs. 26 and 28 clearly indicate that back vowels and /a/ are normally more fronted in the pal. context than in the dent. and, in particular, lab. contexts.

All this said, it is believed here that further elements to explain the variability patterns reported above could come from a more articulatory-based approach. In this respect, it is possible for C-to-V effects to be 'conditioned by the relative compatibility between the articulatory gestures for adjacent vowels and consonants', and that, in general 'effects become

[199] Following (among others) Schwartz et al. (1997), the label 'peripheral' is attributed here to front-unrounded and back-rounded vowels. See the same study for actual examples of peripheral vs. non-peripheral vowels in different languages.
[200] In this respect, according to the data in Fig. 22, the gaps between the most different contexts were never larger than 20 Hz on the height dimension.

most prominent when the target vowel is surrounded by consonants produced with antagonistic gestures' (R&E 2006:665).[201] This approach could provide an explanation as to why, for example, the coarticulatory effects induced by the three contexts chosen in the present study were more visible for back than for front vowels on the F2 dimension. The advanced tongue dorsum required to produce pal. and dent. consonants may in fact induce back vowels to be realised as somehow less retracted, whereas the lab. consonantal environment would leave greater freedom for the tongue to reach its canonical (i.e. more retracted) position. As regards front vowels, the lab. context would still leave the tongue enough freedom to reach (or get close to) the target position, while, at the same time, the less antagonistic gestures needed to produce front vowels in a pal. or dent. environment should cause them to present less context-dependent variation.

Another issue which can be dealt with in articulatory-based terms concerns the higher coarticulatory resistance on the F1 vs. F2 axis. In fact, the relative freedom (referred to a few lines earlier) of the tongue in a bilabial environment to reach its expected release while articulating back vowels would be strictly limited in the vertical dimension, due to the expected high position of the jaw until the moment of plosion. Needless to say, the same considerations apply also to vowels flanked by pal. and dent. consonants. This means, on the one hand, that it is still possible to predict typical context-dependent patterns on the F1 axis too, while, on the other, lesser C-to-V differences can be expected in the same dimension, since the initial position for a vertical movement should be not too different across consonantal contexts, or at least among the three contexts dealt with in the present work, with the tongue adhering to the passive articulators in the pal. and dent. consonant contexts, and not being too far from them in the lab. context.

6.3.4 Final remarks on the ADT predictions about the Catalan and Sardinian data

Sections 6.3.1 to 6.3.2.2 covered the testing of two predictions of the Adaptive Dispersion Theory against data from the Sard. and Cat. varieties. In this respect, the results challenge both predictions, in that no clear positive correlation has been found between inventory size and vowel expansion, while, at the same time, no general inverse relationship has been detected between the number of contrastive vowels and the degree of vowel coarticulatory resistance. Prediction testing was carried out across nine varieties, namely five Cat. and four

[201] For further details see also Recasens, 1985.

Sard., possessing a different number of contrastive vowels (i.e. five, seven and eight, as shown in Fig. 24).

Two alternative ways of defining the inventory size for the Sard. varieties were also dealt with in view of the fact that, on the one hand, some scholars claim that Camp. possesses five vowel phonemes (the five-phoneme approach) and, on the other, that Sard. varieties exhibit an allophonic distribution similar to that of heptaphonemic inventories (the seven-phoneme approach). In none of these cases, however, were the differences in dispersion and variability across dialects attributable to inventory size.

By contrast, some other variables seemed to play an active role in determining the degree of formant frequency shift across the varieties under investigation, such as vowel quality (i.e. back vowels and /a/ showed less articulatory resistance than front vowels) and direction of formant frequency shift (i.e. a higher variability was found to occur along the horizontal axis).

These findings were accounted for by assuming that the degree and direction of the formant shifts are affected by the antagonistic gestures of the flanking consonants. Nonetheless, the possibility was not excluded of the less apparent F1 vs. F2 shift in Algh. and Sard. also being due to systemic factors, such as the need for vowels to avoid confusion, which, in the systems under investigation, can be better achieved by reducing the degree of F1 variability.

6.4 Unstressed mid vowel reduction in Sardinian

In the preliminary phase, the study on Sard. unstressed mid vowels only concerned the testing of the two models of acoustic reduction dealt with in Chapter 3. The same study was later extended with the inclusion of an exploratory investigation of the exceptions to Sard. metaphony and with the evaluation of the effect of specific language-dependent factors on acoustic vowel reduction.

In § 6.4.1 the mean formant frequency values for the vowels in question will be given both cross-dialectally and for the individual Sard. varieties, and discussed as a function of different factors, such as vowel duration and the presence of stress. Section 6.4.2 will be devoted to further investigating the factors possibly playing a role in increasing the probabilities of some vowels ‘jumping over’ their expected collocation on the vowel space, and, in so doing, apparently approaching the space occupied by other vowels. In § 6.4.2 and § 6.4.3ff. a

possible language-related explanation will be proposed to account for the greater instability of Sard. close-mid vs. open-mid vowels.

6.4.1 Formant frequency shifts as a function of AT-x position, consonantal context, vowel and vowel duration

Some data from Contini (1987) on the differences between Sard. stressed and unstressed vowels shown in § Fig. 16 above suggest that in some cases the stress-dependent formant frequency shifts occurring in the three Sard. varieties do not follow the phonetic reduction patterns predicted either by the centralisation-based model (CBM) or the undershoot-based model (UBM). More specifically, none of the unstressed open-mid vowels /ɛ, ɔ/ were produced higher than their stressed counterparts, as would happen if the same vowels headed towards the schwa region (CBM) or followed the overall raising of the vowel space (UBM). Another interesting aspect of Contini's results is that for at least two of the three considered varieties (NLog. and Nuor.), close-mid vowels seemed to be less resistant than their open-mid cognates in terms of vertical shift.

A possible problem in evaluating Contini's data with respect to phonetic reduction patterns was seen, in § 3.3, to be the lack of detailed information about the phonetic environment surrounding the target vowels, with the consequence that the effects of context-dependent variation could not be isolated from those directly related to phonetic reduction. In this respect, an effort has been made in the present work to isolate the role played by coarticulation in determining the degree and direction of formant frequency shifts, and also to evaluate the same effects as a function of other variables such as vowel formant frequency and duration in the 'n' or 'x' preaccentual position (AT-x). The corpus was recorded in similar environmental conditions (i.e. in quiet environments), using the same procedure for all the speakers (i.e. translation into local varieties of short Italian phrases) so as to obtain as far as possible a homogeneous speech style.

The unnormalised F1 and F2 data extracted from the corpus were averaged across the speakers of each Sard. variety as a function of AT-x position (i.e. TO vs. AT-1, AT-2 and, in a specific example of Camp., TO vs. AT-3), consonantal context (i.e. dent. vs. lab.) and vowel quality (i.e. /e, o, ɛ, ɔ/ for TO vs. AT-1, /e, o/ for TO vs. AT-2, and /o/dent. for TO vs. AT-3 in Camp.). The results are reported in Table 24 and Fig. 30.

		/e/				/o/				/ɛ/				/ɔ/			
		dent.		lab.		dent.		lab.		dent.		lab.		dent.		lab.	
		F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2	F1	F2
CLog.	TO	428	1928	422	1892	419	1008	413	933	573	1671	558	1703	543	1024	528	1012
	AT-1	436	1774	439	1774	442	1072	418	922	538	1508	558	1548	524	1097	526	983
	AT-2	450	1725	443	1553	434	1108	435	970								
Camp.	TO	450	1992	443	1971	437	959	451	924	564	1804	556	1840	533	1040	520	976
	AT-1	458	1830	472	1810	454	1036	455	953	576	1542	570	1590	545	1093	554	1056
	AT-2	482	1760	495	1749	489	1111	473	989								
	AT-3					484	1112										
Nuor.	TO	416	2115	420	2041	433	1012	431	939	578	1900	559	1917	556	1065	551	1024
	AT-1	416	1940	438	1881	473	1144	437	962	565	1675	562	1640	547	1115	552	1057
	AT-2	465	1942	466	1859	462	1155	463	1025								
NLog.	TO	429	1999	422	1999	427	964	423	922	541	1817	534	1847	538	1034	517	983
	AT-1	425	1798	441	1766	439	1140	410	949	534	1562	561	1543	534	1108	518	1010
	AT-2	444	1777	450	1660	448	1147	433	974								
Sard.	TO	431	2008	427	1976	429	986	429	930	564	1798	552	1827	543	1041	529	998
	AT-1	434	1836	447	1808	452	1098	430	946	554	1572	563	1580	537	1103	538	1026
	AT-2	460	1801	463	1705	458	1130	451	989								

Table 24: Mean formant frequency values (F1, F2), in Hz, for stressed and unstressed Sard. mid vowels as a function of AT-x position and consonantal context. Data have been calculated for individual dialects and cross-dialectally.

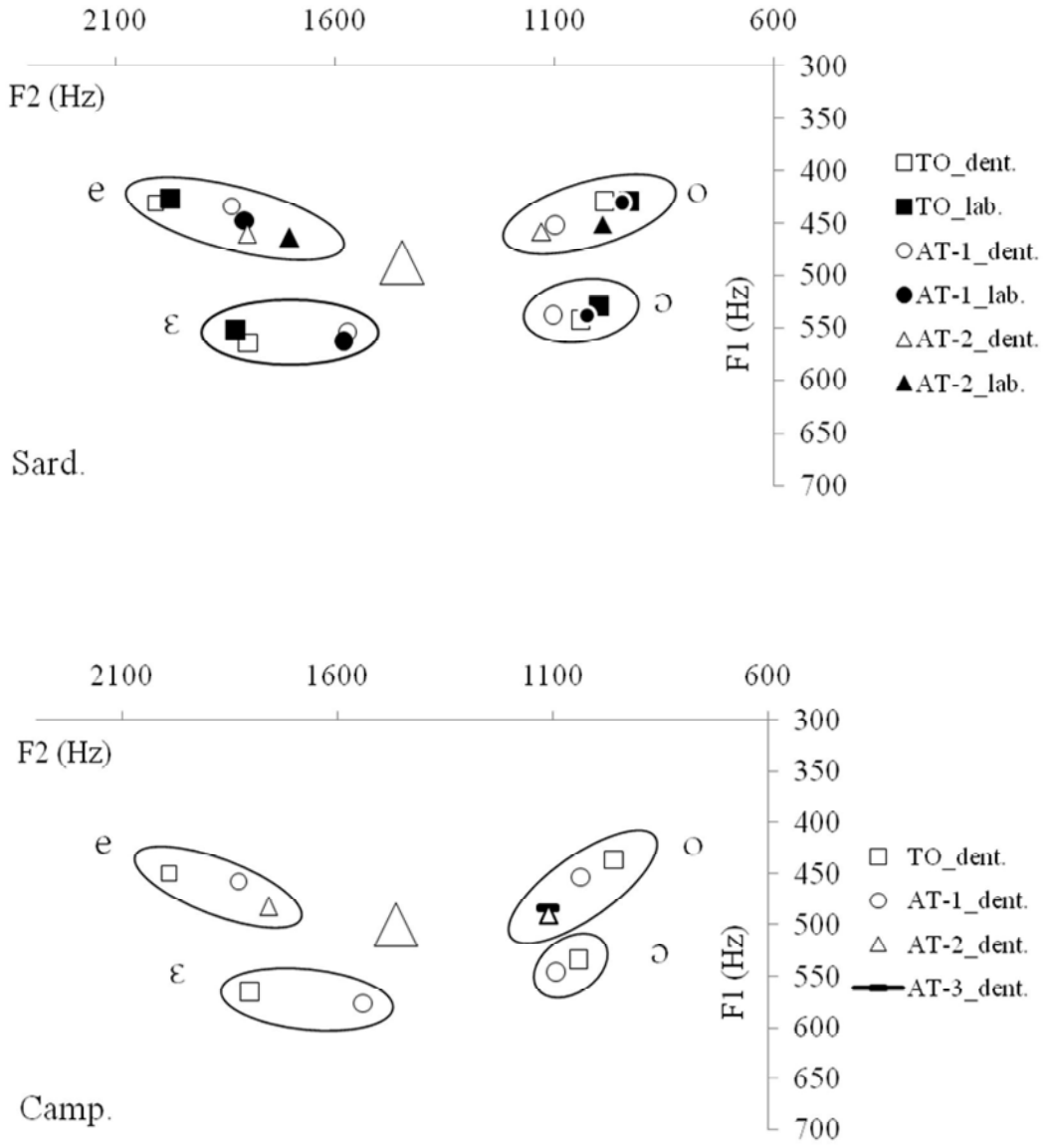


Figure 30: (Top graph) Graphic representation of the cross-dialectal data shown in Table 24. (Bottom graph) Values for the Camp. mid vowels in the dent. context, plotted in order to evaluate the characteristics of formant frequency shifts for target /o/ in the AT-3 position.

According to the table and the graphs, unstressed vowels present clear acoustic reduction effects, especially on the horizontal axis. Front vowels exhibit greater formant shifts than their back counterparts in the same dimension, whereas it is still unclear whether a general positive correlation can be found between the degree of centralisation/undershoot and the AT-x position, since this seems to be true for the AT-1 vs. AT-2 mean values in the case of [e]lab.,

but is not so clear in the case of [e]dent. or of [o]dent. The effects of AT-x position on the degree of horizontal centralisation are, however, far more clearly visible for all the Camp. vowels (in the dent. context), in the progression TO>AT-1>AT-2, while no visible differences are found along either the horizontal or the vertical axis between AT-2 and AT-3. No clear correlation between the degree of formant frequency shift on the fronting dimension and consonantal context seems to be present either (at least at this level of analysis), since the more retracted realisations of [e]lab. appear to be counterbalanced by a less anterior production of [o] in the same context. These preliminary data on horizontal centralisation are consistent with both CBM and UBM.

With regard to the vertical axis, an interesting finding is that no visible rising is detected for unstressed open-mid vowels, contrary to the predictions of both UBM and CBM and consistently with the results from Contini (1987). Another interesting fact suggested by our data is that close-mid vowels proved to be less stable (i.e. they undergo visible formant shifts) on the same dimension than their open-mid counterparts, consistently with Contini's results for NLog. and Nuor.

In terms of the role of AT-x position in determining the degree of formant shifts, close-mid vowels were shown to become lower in the progression TO>AT-1>AT-2, although this was not the case in the only example testing the difference between the AT-2 and AT-3 position (i.e. Camp. /o/dent.), in which the two mean F1xF2 values seemed to be quite similar at the two locations. The normal lowering of unstressed Sard. close-mid vowels would be more consistent with CBM than with UBM, in that the latter assumes a normal rising of unstressed mid-vowels, whereas the former predicts a shift towards the central area of the vowel space, as would seem to be our case. However, the question of why this vertical shift only seems to affect close-mid and not open-mid vowels remains unanswered.

Our data seem, in many respects, to be consistent with the corresponding data in Contini (1987), shown in Fig. 16 above. In fact, Sard. open-mid vowels (cross-dialectally) do not undergo a visible rising, in clear contrast with both CBM and UBM predictions. Also, a certain degree of lowering is visible in our data for close-mid vowels, consistently with the corresponding results for NLog. and Nuor. in Contini's work. A difference between Contini's data and those presented here in Table 24 concerns the horizontal shift of unstressed [e] in NLog., since the same vowel was found by Contini to be more peripheral, whereas in the

present work the shift along the fronting dimension takes place for the same variety in a more centralised way, consistently with both CBM and UBM (see Fig. 31).

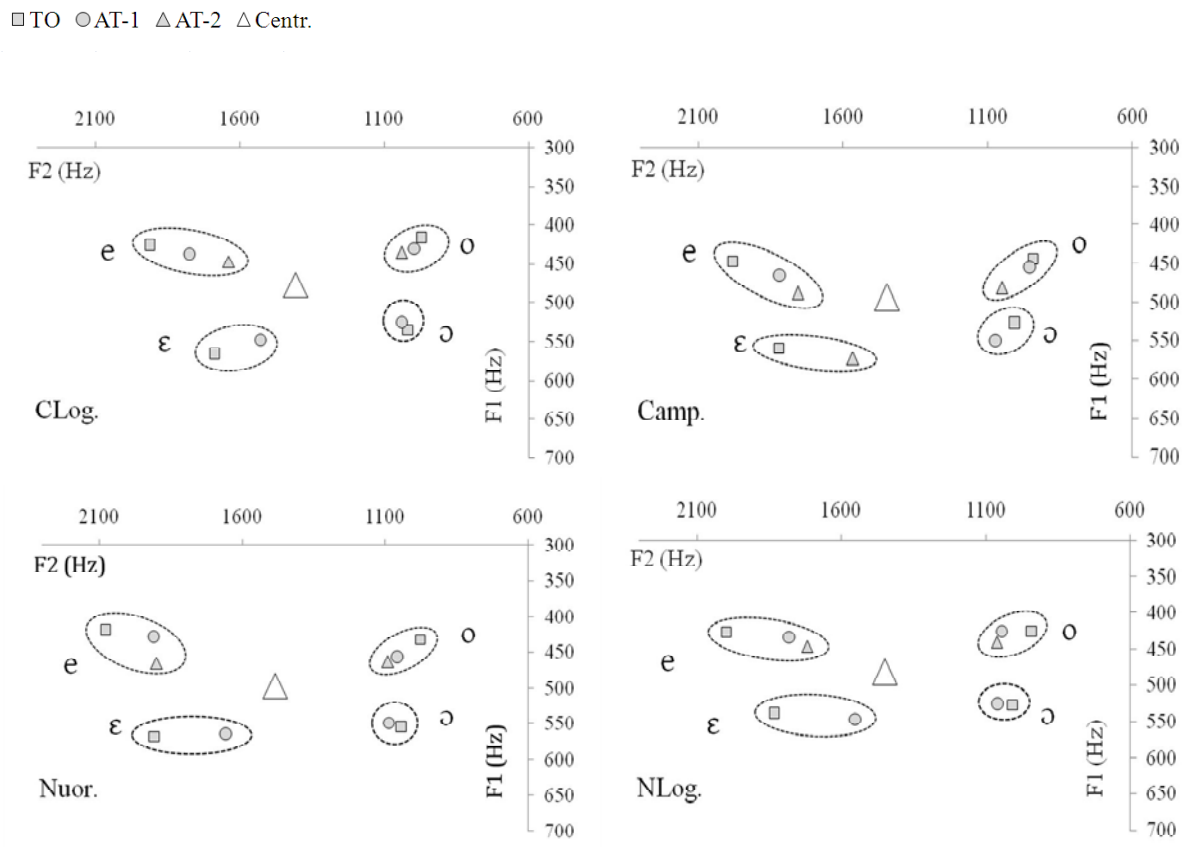


Figure 31: Graphic representation of data reported in Table 24 for the individual Sard. varieties. Formant frequency values for each vowel have been averaged across the two consonantal contexts (i.e. dent. and lab.).

Data for the individual varieties do not seem to change much with respect to the cross-dialectal formant frequency values plotted in Fig. 30 (top). In fact, mid vowels in each Sard. dialect undergo visible horizontal centralisation (in accordance with both UBM and CBM), especially for the front vs. back series, while, with respect to the height dimension, all the individual varieties exhibit clear centralisation in the close-mid series, as predicted by CBM and consistently with Contini's results for NLog. and Nuor. The general trend shown in Fig. 30, whereby open-mid series do not undergo rising, would appear to be confirmed, in accordance with Contini's results and in contrast to UBM and CBM. This fact is quite clear in Fig. 31 for Nuor. and NLog. /ɛ, ɔ/ and for CLog. /ɔ/, whereas CLog. /ɛ/ and Camp. /ɛ, ɔ/ appear to be slightly raised and lowered, respectively. The same graphs also show that the degree of vertical shift for close-mid vowels normally increases as a function of AT-x, in that

the greater the distance from the stressed vowel, the lower (or less close) the unstressed vowels.

The results presented and discussed so far with regard to the reduction of Sard. mid vowels support the trend for all the vowels to converge towards the centre of the vowel space on the fronting dimension, as predicted by both UBM and CBM, and also in partial accordance with the data from Contini (1987). By contrast, the findings about the height dimension challenge both reduction models, since close-mid vowels normally undergo lowering, which runs contrary to the prediction of UBM, while their open-mid cognates are quite stable and do not normally undergo raising, which is against the predictions of both UBM and CBM and accords with Contini's data.

As regards vowel duration, it was seen in § 3.2 that this is normally considered one of the main variables causing acoustic reduction. Factors such as a more formal speech style (van Bergem, 1993, Van Son, 1993) and an increase in articulatory effort (Lindblom, 1990) were also seen as potentially increasing the possibility of the articulators achieving the vowel target even in a reduced time of articulation. In the present study the possibility that speaking-style dependent variability may also condition the degree of undershoot was duly taken into account, and efforts were made to minimise possible related effects on the corpus by obtaining the vowel productions in similar environmental conditions, with informants instructed to produce speech utterances at a comfortable rate, after some training.[202] Consequently, the differences between the reduction patterns for close-mid vowels (i.e. normally presenting a lowering shift) and for open-mid vowels (i.e. being more stable) should depend on differences in vowel duration, in that the more stable open-mid vowels are expected to be longer than the close-mid ones.

But how much longer? Flemming's adaptation of Lindblom's undershoot model reported in Fig. 14(b) above sets 160 ms as a possible boundary below which the effects of coarticulation should be also visible at the vowel midpoint (i.e. vowels should present undershoot effects), and over which no visible coarticulatory effects are expected. It should be added that the author tries to include in his model such variables as articulatory effort and articulatory

[202] The corpus also tried to isolate other variables, such as the locus-target distance (Lindblom, 1994), by embedding different vowels in similar consonantal contexts, and word type (van Bergem, 1993), by excluding monosyllabic function words from the candidate target words.

distance between the target vowel and its adjacent segments, with the consequence that the boundary of 160 ms might vary in some conditions. As indicated a few lines above, efforts were made in the context of the present work to obtain the corpus at a comfortable speech rate and following some training of the informants, with the result that the variable articulatory effort should not cause the 160 ms boundary to change much. As regards the articulatory distance between the target vowel and its adjacent segments, Flemming's boundary is also expected to account for such typical consonantal contexts as lab., pal. and dent., and consequently no context-dependent shifts ought to occur close to or above the 160 ms boundary.

This prediction can be tested by displaying the durations of Camp. vowels shown in Table 16 together with the mean formant frequency values for the same vowels as a function of consonant context extracted from Table 22. The results are shown in Fig. 32.

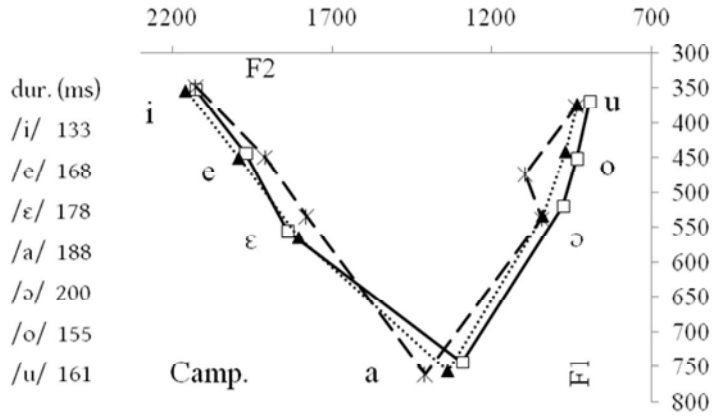


Figure 32: Context-dependent formant frequencies, in Hz, for Camp. stressed vowels. It should be noted that some vowels do present contextual variation even though their duration equals (/o/) or exceeds (/a, ɛ/) the 160 ms boundary set by Flemming (2005:12).

The graph shows some examples of vowels presenting visible context-dependent formant frequency variability even though their duration is quite close to Flemming's 160 ms boundary (i.e. /o/ = 155 ms). In the case of /ɛ/ and /a/, context-dependent formant frequency shifts are visible for vowel durations exceeding Flemming's boundary by almost 20 and 30 ms, respectively.

For our purposes, testing Flemming's duration boundary against a Sard. variety revealed some undershoot effects also for stressed vowels with durations close to or even greater than 160

ms. In some cases (e.g. /ɛ/ and /o/), context-dependent formant shifts were also found to occur on the height dimension, so the lack of visible acoustic reduction effects on the same axis found for unstressed open-mid vowels could be justified by (counterintuitively) hypothesising that the same vowels possess an equal or even longer duration than their stressed counterparts. Similarly, close-mid unstressed vowels are expected to be shorter than their more stable open-mid counterparts, while those in AT-2 position are expected to be shorter than their cognates in AT-1, with the latter showing less vertical formant frequency displacement.

To investigate these possibilities, data for vowel duration, expressed in milliseconds (ms), are reported for Sard. (cross-dialectally) in Table 25, as a function of vowel quality and AT-x. The rightmost values included in row 'a)' correspond to the mean vowel durations for Sard. stressed mid vowels across dent. and lab. contexts.

a)	AT-1	AT-2	AT	TO		
	63	60	62	140		
b)	/e/	/o/	/ɛ/	/ɔ/	/e, o/	/ɛ, ɔ/
	58	65	59	68	61	63
c)	/e/ AT-1	/e/ AT-2	/o/ AT-1	/o/ AT-2	/e, o/ AT-1	/e, o/ AT-2
	56	59	68	62	62	60

Table 25: Mean duration values, in ms, for Sard. stressed and unstressed mid vowels. Values are displayed as a function of AT-x. The rightmost columns of row 'b)' include the mean duration values for close-mid vowels (/e, o/) and open-mid vowels (/ɛ, ɔ/), and those of row 'c)' the mean values for close-mid vowels in pretonic position (/e, o/ AT-1) and pre-pretonic position (/e, o/ AT-2).

The data reported in Table 25 can be read in different ways. The most general consideration is that, to some extent, the centralised formant shifts on the horizontal axis for unstressed vowels can be attributed to the considerable difference in duration between stressed and unstressed vowels (140 ms for the former compared to 62 ms for the latter). On the other hand, some inconsistencies can be found if the (greater) degree of vertical formant shift for close-mid vowels is only attributed to (shorter) vowel duration, for two reasons.

The first is that, according to the table, the difference in duration between close-mid and open-mid vowels is hardly visible (61 ms and 63 ms, respectively), and hence the latter series would also be expected to undergo vertical shifts. To dispel the possibility that such a short difference in duration could play an important role in making open-mid vowels more stable

than their close-mid cognates, it would be sufficient to point out that unstressed /o/ is, on average, 6 ms longer than unstressed /ɛ/ (see Table 25, row b)); in this respect, if it is true that a few milliseconds can make a vowel more resistant to reduction, the unstressed close-mid vowel /o/ should consequently show less, not more vertical formant shift than /ɛ/.

The second reason is that, in a similar way, the duration values for the AT-2 vowels would be expected to be shorter than the corresponding AT-1 values, since the former category exhibited greater F1 shift than the latter. Contrary to the expectation, however, the difference between the two series was just 2 ms (the values were 60 ms and 62 ms, respectively), and thus similar to the difference between open-mid and close-mid vowels seen in the previous paragraph, making it quite improbable for this correlation to hold in general terms.

So far, the variable 'vowel duration' has been seen to possibly affect the degree of horizontal centralisation for TO vs. AT Sard. mid vowels, given that a considerable mean difference in duration has been found in our data between the two series (140 ms and 62 ms, respectively), and also that a reduction effect on the fronting dimension has been seen to somewhat affect all the unstressed mid vowels (see Figs. 30 and 31 above). The same data, however, do not yet appear to provide any explanation of why the mean F1 of stressed open-mid vowels is practically identical to that of their unstressed counterparts (i.e. 547 Hz and 548 Hz, respectively), while the F1 shift for close-mid vowels has been found to increase in the order TO>AT-1>AT-2 (i.e. 429 Hz, 441 Hz and 458 Hz, respectively).[203]

In the process of looking for complementary methods to further analyse these issues, the helpful discovery was made that some unstressed Sard. vowels are realised in rather unexpected ways – for example the [e] (AT-1) of the first name 'P**e**pina', which was uttered, albeit very rarely, with an open-mid quality: 'P[ɛ]pina'. This fact provided the author of the present study with an important clue that more information on the dynamics underlying the acoustic reduction process in Sard. mid vowels could come from the second last variable listed in § 3.2, namely 'language-dependent factors'. This issue will be dealt with in detail in the following sections.

[203] These figures have been computed over the individual values shown in the Sard. section of Table 24.

6.4.2 Some remarks on Sardinian 'jumps'

The realisation of the mid vowel in the example of 'P[ɛ]pina' given at the end of the previous section was considered unexpected, since this vowel is directly followed by a close one and should consequently have been uttered as [e] according to the Sard. metaphony rule. In this respect, the possibility was further taken into consideration of this and similar exceptions having somehow played a role in influencing the overall degree of vertical formant frequency shift for Sard. close-mid vowels. Nonetheless, in following the procedure described in § 5.6.2.2 to identify the overall number of these exceptions ('jumps'[204]), a considerable number of vowels *intermediate* on the vertical dimension ('interm.') were found. The total number of jumps and intermediate vowels are displayed in Table 26 as a function of 'vowel quality' for the open-mid and close-mid series. Given the fact that in Figs. 30 and 31 the close-mid vowels were found to be, on average, more centralised on the same dimension than their open-mid counterparts, a higher number of jumps and intermediate vowels in the former series would be considered among the factors possibly causing the greater centralisation, on the vertical axis, of /e, o/.

Sard.

vowel	tokens	interm.	%	jumps	%
/e, o/	818	176	21.5	57	7.0
/ɛ, ɔ/	397	26	6.5	4	1.0
tot.	1215	202	16.6	61	5.0

Table 26: (Columns 5 and 6) Number and percentages of jumps involving Sard. mid vowels. (Columns 3 and 4) Number and percentages of intermediate realizations around halfway between /e/ and /ɛ/ and between /o/ and /ɔ/.

According to the table, the overall numbers of jumps and intermediate vowels accounted for, respectively, 5.0% and 16.6% of the 1,215 vowels analysed. The expected close-mid vowels are seen to present a higher percentage of both intermediate and jump realisations than their open-mid counterparts, in a ratio of roughly 10:3 (21.5% and 6.5%) and 7:1, respectively.

The possible incidence of the higher percentage of jumps and intermediate vowels on the overall F1 means has been further quantified by dividing the 1,215 unstressed vowels into three groups, the first including all the jumps, the second including all the intermediate vowels, and the third including the remaining vowels, here called 'unaffected'. The F1 values

[204] It is useful to remember that 'jump' also refers to expected open-mid vowels pronounced as close-mid.

of each vowel were then averaged again within each group, and the mean data of unaffected vowels were compared with the corresponding data for intermediate vowels and jumps. As a result, intermediate vowels and jumps presented F1 shifts amounting to, respectively, 7.2% and 14.5% of the F1 frequency of the unaffected vowels.

For example, in the case of a mean F1 value for an unaffected close-mid vowel of 450 Hz, the corresponding mean values for intermediate vowels and jumps would be 482 Hz (450 + 7.2%) and 515 Hz (450 + 14.5%) respectively. Conversely, applying the same percentage to an unaffected open-mid vowel with an F1 value of 550 Hz, the corresponding values for intermediate vowels and jumps from the same series would be 510 Hz (550 - 7.2%) and 470 Hz (550 - 14.5%) respectively. It seems clear from these data that the overall degree of centralisation on the vertical axis (i.e. lowering for close-mid vowels and rising for open-mid ones) might be increased to some extent by a higher presence of intermediate vowels and jumps.

The following analyses are aimed at finding a possible explanation of why close-mid vowels appear to undergo more F1 acoustic reduction than open-mid vowels. This aim will be pursued through a detailed investigation of the data concerning jumps. In this respect, Table 27 presents the number of jumps as a function of vowel quality and AT-x position.

Sard.	vowel	tokens	jumps	%
AT-1	/e/	196	8	4.1
	/o/	198	6	3.0
	/ɛ/	200	1	0.5
	/ɔ/	197	3	1.5
	/e, o/	394	14	3.6
	/ɛ, ɔ/	397	4	1.0
AT-2	/e/	199	23	11.6
	/o/	200	14	7.0
	/e, o/	399	37	9.3
	tot.	1215	61	5.0

Table 27: Number of jumps as a function of vowel quality and AT-x position across the Sard. varieties.

According to the table, when the variable AT-1 is isolated (i.e. when vowels are compared in the same AT-1 position), the ratio of the number of jumps in close-mid vowels to those in

open-mid vowels decreases from 7:1 to 7:2 (3.6% and 1.0%). Also, when the same comparison is carried out within the close-mid category in AT-1 vs. AT-2 position, the percentage of jumps increases from 3.6% to 9.3% respectively, suggesting that the greater the distance from the stressed vowel, the higher the chances of it being uttered as a jump (similarly to the finding in § 6.4.1 concerning the direct relationship between the lower articulation of unstressed close-mid vowels and their greater distance from the stressed vowel). This possibility would be also supported by the data for the only (exploratory) example of a close-mid vowel in AT-3 position recorded in our corpus (see Fig. 33).

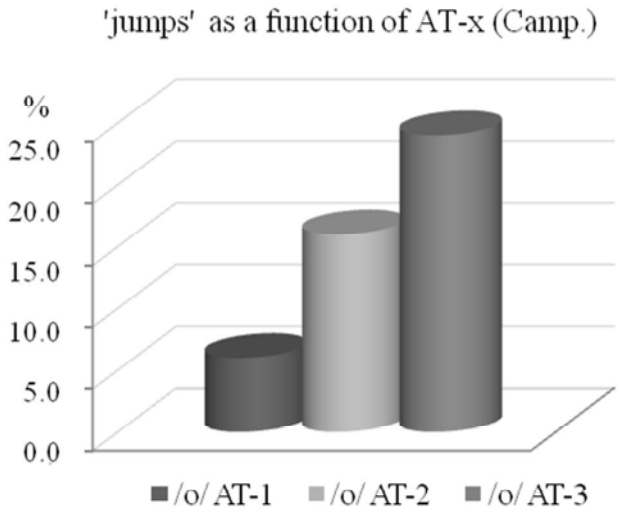


Figure 33: Percentage of jumps for Camp. close-mid vowels as a function of AT-x position.

The values shown in the graph can be considered a further clue that the variable AT-x can play a role in modifying the percentage of jumps, although it should not be forgotten that jumps only constitute a small percentage (5%) of the overall 1,215 unstressed Sard. vowels analysed. When data for individual varieties are considered, the absolute number of tokens and jumps decreases considerably, hence some prudence is required when evaluating the results. With respect to the data presented in Fig. 33, the percentage of jumps for each category was obtained across 125 repetitions, i.e. 50 tokens for /o/ at AT-1 (3 jumps), 50 for /o/ at AT-2 (8 jumps) and 25 for /o/ at AT-3 (6 jumps).

The results dealt with so far indicate that the difference in vertical centralisation between close-mid and open-mid vowels might be due to some extent to the higher presence, in the former, of intermediate vowels and jumps. This, however, still does not answer the question of why close-mid vowels present more jumps and intermediate realisations than open-mid vowels, or why the percentage of jumps and intermediate realisations increases in parallel with their distance from the vowel carrying the primary stress.

To return to the variable 'vowel duration', this was seen in Table 25 not to have much influence on the greater formant shifts from close-mid to open-mid unstressed vowels or viceversa, and from AT-2 to AT-1 unstressed vowels or viceversa. However, it should not be excluded that further information on possible correlations between vowel duration and overall formant frequency shifts may be obtained by comparing the duration of individual jumps with the mean *duration* value of non-jumps. In order to investigate this possibility, the duration of each jump was compared to the corresponding mean vowel duration in the same category, where 'category' means the same vowel phoneme in the same AT-x context and for the same dialect. The results are given Fig. 34(a) for AT-1 vowels and in Fig. 34(b) for the corresponding AT-2 vowels.[205]

[205] In the graph, when a 'jump' (i.e. a vowel that 'jumped over' its expected collocation on the vowel space) is represented with an 'e' or an 'o', this means that the expected quality of these vowels was close-mid, and, at the same time, that their actual realization was found to be open-mid instead. Similarly, 'ɛ' and 'ɔ' shown in the same graph represent expected open-mid vowels which were actually spoken as [e] and [o], respectively.

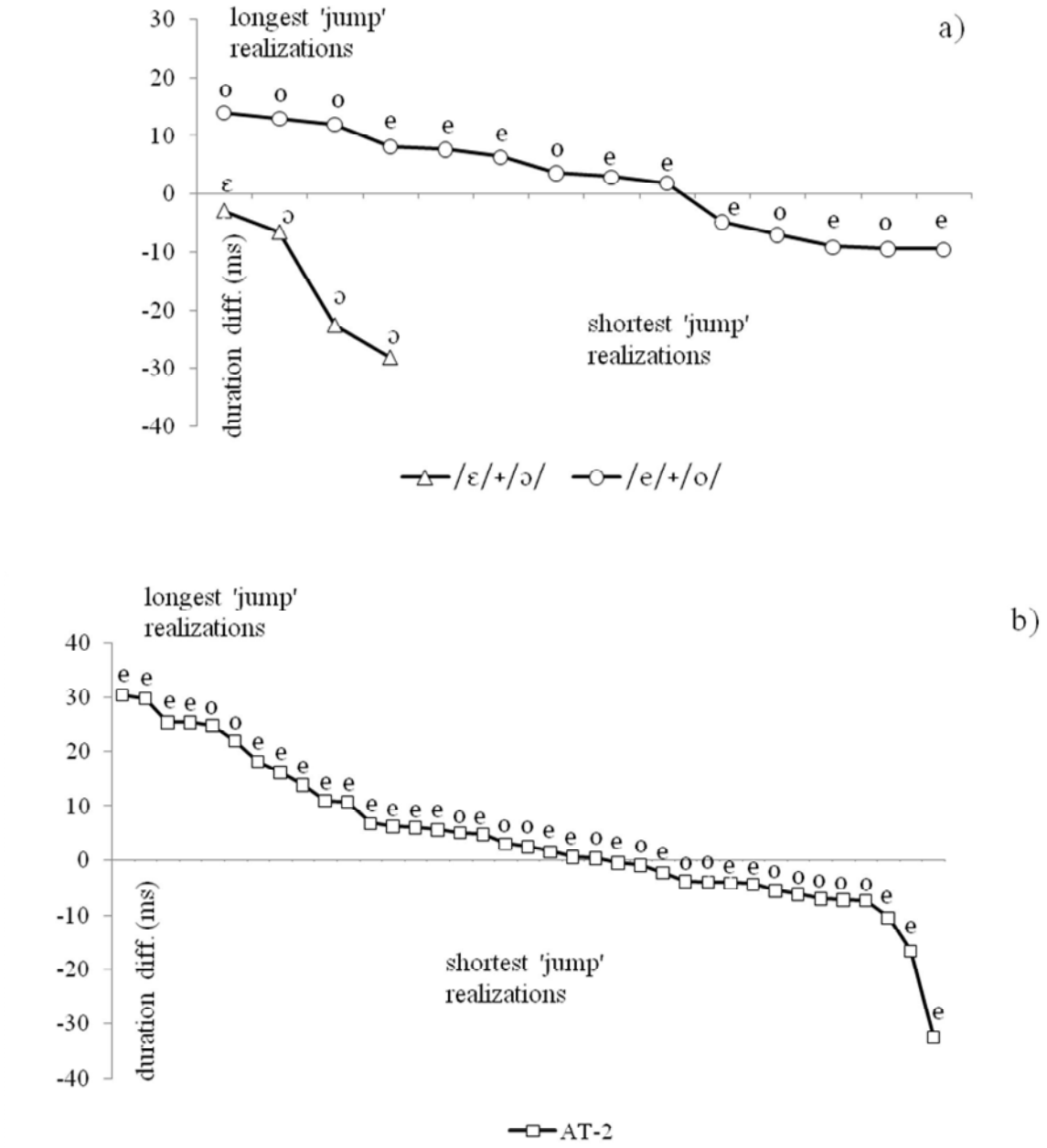


Figure 34: Jumps in AT-1 (a) and AT-2 position (b). Each vowel shown above and below the '0' line is to be considered as respectively longer and shorter than non-jump vowels in the same AT-x position and for the same dialect.

According to Fig. 34(a), the few cases of jumps among open-mid vowels (four) can still be attributed to the variable 'duration', in that they are normally uttered as shorter or much shorter than the corresponding vowels in the same /ɛ, ɔ/ category. In this respect, these realisations would be more consistent with Flemming's undershoot-based model (UBM), in

that a shorter duration in a lab. or dent. context may not have left the articulators enough time to reach the canonical /ɛ/ or /ɔ/ position.

As pointed out by different authors (Lindblom, 1990; Van Bergem, 1993; Van Son, 1993), shorter duration does not necessarily mean that the target vowel undergoes undershoot or centralisation, while in our corpus some examples were also found of shorter than the average realisations of /ɛ/ and /ɔ/ which did not become either intermediate vowels or jumps (i.e. they did not undergo strong rising shifts). As regards the open-mid jumps in Fig. 34(a), however, the assumption that shorter realisations are more likely to undergo formant frequency shifts in a similar speech style is considered here sufficient to attribute the cause of the rare *closing* jumps to (shorter) duration.

As regards *opening* jumps (i.e. expected close-mid vowels uttered instead as open-mid), both Figs. 34(a) and (b) indicate that no general correlation can be found between shorter duration and higher F1 shift, in that the tokens in question are seen to spread both over the upper and left quadrants (i.e. areas including the longest realisations) and towards the lower and right quadrants (i.e. shorter realisations).

The interpretation of the results becomes even more intriguing in the light of the predictions of both the centralisation-based model and the undershoot-based model. The CBM would, in fact, normally predict for shorter close-mid realisations a formant frequency shift heading towards the central areas of the vowel space, and not a 'jumping over' into the area of the corresponding open-mid vowels. As regards longer vowels, both CBM and UBM would predict a lower degree of acoustic reduction and a greater likelihood of reaching their canonical position than shorter vowels; by contrast, examples of great formant frequency shifts from expected realisations (i.e. jumps) are also found among longer vowels in both graphs. In this respect, jumps seem to be fairly similarly distributed among both longer and shorter realisations. Finally, it should be added that the presence of jumps among shorter vowels would also disagree with UBM, in that close-mid vowels are not expected to be pronounced as open-mid in shorter realisations, especially when they are flanked by such consonants as [b], [t] or [s]. In fact, in these and other consonantal environments requiring the jaw to be raised (such as for [b]) and a certain amount of contact between the tongue and areas of the hard palate and/or the alveolar ridge to occur (such as for the dentoalveolars [t, s]), a shorter duration should cause coarticulation effects to be greater, not smaller.

Consequently, the close-mid vowels [e, o] are not expected to be pronounced as [ɛ, ɔ] (or [ɛ̝, ɔ̝]), but rather as [e, o] and even [e̝, o̝].

To sum up, a certain influence of the variable 'vowel duration' can thus far be reasonably hypothesised to explain the presence of jumps among *open-mid* vowels, in that the few examples in question were all found to be shorter or much shorter, on average, than the other vowels in the same AT-1 category and dialect. In this respect, the possibility cannot be excluded that those jumps are partially or mainly caused by the coarticulatory pressure exerted by flanking consonants (Flemming, 2005), and even by articulatory imprecision or laxness as evoked by Lindblom (1963). This explanation, however, does not appear to be satisfactory in the case of *close-mid* jumps, since these have been seen to be present among both longer and shorter than average vowels.

6.4.3 Formant frequency shifts as a function of language-dependent factors

It should now be clear that some of the findings presented in the previous sections dealing with F1 shifts in Sard. unstressed mid vowels (such as the differences in vertical acoustic reduction exhibited by close-mid vs. open-mid vowels, the former series generally undergoing raising and the latter exhibiting no visible F1 shift) cannot be totally explained by means of UBM and CBM. Neither model, moreover, seems able to account for the jump cases affecting specially close-mid vowels. For these reasons, in the lines that follow a possible theoretical framework will be proposed to better interpret the results discussed so far, with particular regard to the possible causes affecting the percentage of jumps. Special attention will be paid to the two concepts of 'normal vowel production' (i.e. open-mid) of Sard. mid vowels and 'metaphonic pressure'. Some new information will also be added in order to better understand whether the variable 'vowel duration' can actually affect the percentage of jumps and, if so, in what terms and to what extent.

As seen above in § 2.3, Sard. metaphony is normally described as the raising of a mid vowel when it is directly followed by a close or a close-mid vowel, such as in Log. '[ˈo]ru' ('edge'). It was also seen that this exclusively phonetically-based description is not sufficient to account for the evolution of this rule in Camp., since this variety also presents such pronunciations as '[ˈɔ]ru', i.e. the original Sard. word '[ˈɔ]ro' ('gold') affected in a given moment of its history by the Camp. lexical reduction '[ˈɔ]r[**ɔ**]→[ˈɔ]r[**u**]'. As seen above, the

turning of final [ɔ] into [u] did not affect the original open-mid pronunciation of stressed [ɔ] in this case.

In general, the importance of the phonological dimension in understanding the functioning of certain phenomena of vowel harmony can be proven by the fact that this process sometimes differs across different languages.[206] With regard to Sard., it is believed here that the systemic framework characterising the quality of its mid vowels can be summarised as follows:

a) Sard. mid vowels are naturally open-mid, i.e. they are normally pronounced as such;

b) Sard. mid vowels can be also pronounced as close-mid due to (mainly) metaphonic pressure;

c) when metaphonic pressure is activated on a mid vowel, its quality will be determined by the outcome of two opposite pressures, i.e. the natural tendency to be uttered as open-mid described in point 'a)', and the closing pressure induced by metaphony described in point 'b)'.

With regard to point 'c)', metaphonic pressure normally outweighs the opposite tendency, especially when it affects stressed vowels. If we keep in mind, however, that every metaphonic (i.e. closing) pressure actually competes against an opposite (i.e. opening) tendency, this may make it easier to explain the exceptions to metaphony found and discussed in the previous sections.

For example, it remained unclear why jumps were seen to be more present among close-mid vowels than among open-mid ones, in a ratio of roughly 7:2 in the same AT-1 position (see data for /e, o/ vs. /ɛ, ɔ/ in Table 27). In the light of the theoretical framework proposed above, it would be easy to claim 1) that the actual realisation of the expected close-mid vowels depends phonologically on two opposite tendencies, and 2) that the quality of open-mid vowels depends phonologically on just one factor (i.e. the normal open-mid realisation of Sard. mid vowels): it is therefore probable that since close-mid vowels are the result of two opposite pressures, this makes them less stable than their open-mid counterparts.

[206] See, among others, Contini, 1987:439-441 and Virdis, 1978:25-27 for Sard.; Rohlfs, 1949/1966 § 6 for southern Italian dialects; Zamora-Vicente, 1985 for Leonese; Nunes, 1919/1960 for Portuguese.

With regard to the rare examples of the expected realisations [ɛ] and [ɔ] instead as [e] and [o] (i.e. closing jumps) at AT-1, their lack of stability can be justified in strictly phonetic terms, since their duration was found to be shorter or much shorter than the average of other AT-1 vowels. Consequently, any undershoot pressure exerted by consonantal context would have made them higher in articulation – as was actually the case. This last example allows us to add to the systemic framework described by points 'a)', 'b)' and 'c)' above, the more phonetically oriented point d):

d) the systemically oriented points a), b) and c) have to be complemented by phonetic facts such as the formant frequency shift possibly caused by coarticulation, vowel duration, articulatory effort, and so on.

This theoretical framework would also provide some new keys for understanding how the variable 'vowel duration' can condition the presence of jumps. This variable will only be discussed here with regard to close-mid jumps, since, as we have seen above, open-mid jumps can be satisfactorily explained by vowel duration, as proposed by UBM.

It should be added that a possible explanation of why jumps can be found in both shorter *and* longer realisations can run the risk of being non-falsifiable, in part because its predictive power seems to be limited from the outset by the fact that, in some cases, jumps presented (almost) identical duration to non-jumps. It is nonetheless believed here that it is still possible to detect some of the variables at work in causing jumps to occur in both longer and shorter vowels. The two possibilities will be discussed separately in the two sections that follow.

6.4.3.1 Presence of jumps as a function of *shorter* duration

Among the best known definitions of metaphony is that of Wagner (1941/1984:31), which summarises this process as the raising of mid vowels caused by a following 'original'[207] close vowel, or by a close-mid vowel followed, in turn, by an original close vowel. It is probable that this definition can successfully describe the functioning of Sard. metaphony in the vast majority of its applications in everyday language. It is not impossible, however, that this description, which is normally reported with minor differences by other authors, has oversimplified a much more complex type of harmonic process.

[207] As seen above in § 2.3, in this case 'original' means 'etymological', and it is aimed at excluding the Camp. [i] and [u] which were originally [ɛ] and [ɔ], respectively.

To start with, words such as CLog. (in its Pozzomaggiorese variety) [ˈʤ**o**ʤː**a**], used in our questionnaire, constitute a clear example of a close-mid vowel *not* directly followed by a close or a close-mid one, in contrast with Wagner's definition. Other, similar exceptions to the metaphony rule are reported (albeit very rarely) in the literature,[208] but the functioning and distribution of these exceptions has not (to our knowledge) been dealt with in any specific study. Some exploratory data gathered by the author of the present study on this and other aspects of Sard. metaphony have indicated that a simple phonetic and synchronic approach may not be sufficient to discern why, for example, the phonetic environment following the [o] in [ˈʤ**o**ʤː**a**] (i.e. a palatal consonant + an open vowel) caused the mid vowel to raise and why, by contrast, this does not happen in the same variety when a similar phonetic environment follows the stressed vowel in [ˈ**ɔ**ʤː**ɔ**s] ('eyes') (i.e. a palatal consonant + an open-mid vowel). When this and other similar examples are produced in normal speech, it should not be forgotten that a given speaker usually has a very limited time in which to integrate the most general application of metaphony to these and other possible variations of the rule.

In other cases, too, the general application of metaphony might require a word-specific approach. For example, among the words included in the questionnaires of the present study for CLog. and NLog. there was 'archit[ˈe]tu' ('architect'). The same word was not included in the Camp. questionnaire, given its condition of Italian loan and the consequent treatment of final [u] as a non-etymological close vowel (i.e. coming from Italian 'architett**o**') with the result that the target vowel of this lexical item is pronounced as [ɛ] ([aɾkiˈt**ɛ**tˑ**u**]) in the southern Sard. varieties.[209] By contrast, the derivative 'archit**e**tura' was included in the questionnaire instead, since in all the Sard. varieties, Camp. included, the target vowel 'e' is pronounced as close-mid, consistently with the fact that it is followed by an etymological close vowel (i.e. 'architet**u**ra').

The cases of [ˈʤ**o**ʤː**a**]/[ˈ**ɔ**ʤː**ɔ**s] and [aɾkiˈt**e**tu]/[aɾkiˈt**ɛ**tu]/[aɾkit**e**ˈtuɾa] are just some examples of how the functioning of Sard. metaphony is not as simple as it might seem on the basis of Wagner's description. In this respect, it should not be forgotten that metaphony is a kind of regressive assimilation, in that a given mid vowel is raised at a given moment as a consequence of a mere 'prediction' of what the following vowel(s) is (are). The 'computation'

[208] See, for example, Contini, 1987b, Table 65, and Cossu, 2008, footnote 12.
[209] See Virdis, 1978 for other examples.

phase may be facilitated by the fact that in normal speech we mostly use words we are already acquainted with, such as [ˈʤɔʤːa], in the sense that this and other 'variations' to the most general functioning of metaphony can be interiorised by native speakers and mechanically produced in normal speech. On the other hand, it should not be forgotten that in our corpus 5% of unstressed vowels were found to be pronounced inconsistently with the normal metaphony rule, and that this category should also include the 16.6% of vowels which were found to be intermediate. In this respect, the much shorter duration of AT vs. TO Sard. mid vowels (62 ms and 140 ms) might have left the speakers less time to carry out the *correct* computation of the outcome and consequently caused problems in the production of the *expected* realisation of a given mid vowel.

With regard to the stressed domain, exceptions to metaphony were found to be almost inexistent in our recordings. The two exceptions, produced by one NLog. informant, provide potentially interesting information in support of the hypothesis that the computing of the phonetic outcome is considered a possible factor at play in determining the quality of Sard. mid vowels. In fact, in uttering the word 'archit[e]t[u]', the speaker also produced one example of the 'Italianised' form 'archit[ɛ]t[ɔ]'. When the interviewer asked him which of the two forms could be more suitable in a normal conversation in Sard., he indicated the adapted Sard. form 'archit[e]t[u]'. As a consequence, in the following series he probably had in mind both the possible Sardinian- and Italian-like outcomes, and produced the improbable form 'archit[e]tt[ɔ]', with an Italian (actually Sardinian Regional Italian) final open-mid vowel and a metaphonised previous close-mid vowel. In the series after that, he produced an equally improbable 'archit[ɛ]t[u]', with the open-mid [ɛ] followed by a close vowel. That this kind of violation of Sard. metaphony is very unusual in the northern Sard. varieties is proved by the fact that in both cases the speaker immediately corrected himself by repeating the expected form 'archit[e]t[u]'. What is more striking here is that in some specific conditions the process of computing the effects of vowel *opening* vs. *closing* factors seems to have produced some miscalculations. From this point of view, it is not impossible that jumps are associated, at least in part, with short vowel realizations.

6.4.3.2 Presence of jumps as a function of *longer* duration

As anticipated above in § 6.4.3, in points 'a)' and 'b)', Sard. mid vowels present two typical qualities: they are usually uttered as open-mid when they do not undergo any closing

(typically metaphonic) pressure, and as close-mid when they undergo metaphonic pressure. In the literature consulted for the present study, metaphony is simply and generally described as causing mid vowels to be realised as close-mid, but no quantitative or qualitative investigations of possible exceptions to this process are provided. This is probably because the phenomenon affects mid vowels (especially stressed ones) very regularly in normal speech.[210]

The great regularity of the process may at first sight disguise the fact that a close-mid realisation is not simply caused by the unilateral intervention of a raising pressure, as much as it is the result of two opposite pressures, i.e. the opening pressure of the normal pronunciation of Sard. mid vowels and the closing pressure mainly due to metaphony. The duality of this process can be shown by an example. In Sard., the word 'bene' ('well', 'good') should be pronounced as [ˈb**ɛ**n**ɛ**], with the mid vowels presenting an open-mid quality, consistently with the normal realisation of these vowels in the language in question. By contrast, the mid vowel in the word 'bènnidu' ('come') should be realised as close-mid ([ˈb**e**n:**i**ḍu]), due to the closing pressure of the following [i]. What would happen if the two words were found in the order 'bene bènnidu' in the speech chain? Would the [e] of 'b[e]nnidu' manage to raise, in turn, the mid vowels of the preceding 'b[ɛ]n[ɛ]'? According to Corda (1994:155), metaphony normally affects mid vowels within the word domain,[211] hence 'b[ɛ]n[ɛ]' should in theory maintain both vowels as open-mid. What would happen if, at a given moment, the community of speakers started to treat the sequence of 'bene' and 'bènnidu' as a single compound word (i.e. 'well' + 'come'→ 'welcome')? Would this change automatically cause metaphony to occur throughout the word? And would it occur immediately in all the speakers of the community, or would fluctuation be found across speakers for a given period?

The primary purpose of these questions is to show that it would be at least reductive to consider metaphony as a mere categorical process by which a close (mid) vowel simply activates a rising pressure towards the preceding mid vowels. In this respect, the example 'bene' + 'bènnidu' serves as a possible example of the dynamic process that takes place between a raising pressure (i.e. metaphony) and a lowering one (i.e. the normal open-mid

[210] According to Tables 26 and 27, the number of jumps among the 1,215 analysed unstressed vowels amounted to 61 tokens, i.e. 5.0% of the total. This percentage becomes much lower (1.6%) if the 2,630 stressed vowels are also included in the calculation.
[211] The author includes in his description the possible exception associated with the presence of epithetic [i] introduced in words such as 'p[ɛ]r'→ 'p[e]r**i**' ('across').

pronunciation of Sard. mid vowels). The present study was not originally aimed at investigating specific aspects of Sard. metaphony, hence no examples such as 'benebènnidu' were included in the questionnaire and recorded. Nevertheless some compatible examples can be found in the literature. In a 2010 study,[212] the author of the present work analysed the possible effects of Sard. metaphony on Algh. The first and most important finding of that study was that the variety of Italian spoken in the city of Alghero was heavily affected by Sard. metaphony. The example which will be given here is therefore expected to follow the typical dynamics of the same phenomenon in Sard. In the experiment in question, ten Algh. participants were asked to pronounce the Italian compound word 'ferro['']via' ('railway'). The main aim of this experiment was to verify whether the [i] of the second stem '**v**i**a**' ('way') could affect the mid vowels of the first stem 'ferro' ('iron'), which are normally pronounced, in isolation, as 'f['ɛ]rr[ɔ]'. The experiment was actually designed to obtain two different pronunciations of the same compound word. In one case, this two-stem word was embedded in the phrase 'Costruiscono la ferrovia' ('They are building the railway'), while in the other case the same word was required in isolation. The aim of this variation to the experiment was, following Canepari (2004:152-159),[213] to try and preserve in the word uttered in isolation some acoustic features of the secondary stress (presumably) borne by the leftmost mid vowel 'e', and, in so doing, to verify whether some of the original acoustic properties of the 'e' of 'f[ɛ]rro' (namely its open-mid quality) could also be better preserved. The spectroacoustic results of that experiment in terms of F1 frequency data are reported here in Table 28, with the addition of the mean vowel duration for each set of target vowels.[214]

[212] See Ballone, 2010.
[213] The author claims for Standard (or 'neutral') Italian that in longer phrases some secondary stress can 'attenuare fino a ridursi al grado di 'non-accentazione' ('attenuate until it reaches the unstressed condition') (p. 153).
[214] The results were presented in Ballone (2010) in terms of mean F1 values across speakers.

		realisations	jumps	interm.	unaffected	mean vowel duration
1a)	'Costruiscono la f**e**rro[ˈ]via'	10	6	3	1	63 ms
1b)	'F**e**rro[ˈ]via'	10	10		0	86 ms
2a)	'Costruiscono la ferr**o**[ˈ]via'	10	1	5	4	90 ms
2b)	'Ferr**o**[ˈ]via'	10	5	3	2	86 ms

Table 28: Presence of jumps and intermediate vowel realisations in the Italian word 'ferrovia' pronounced by 10 Algh. speakers. The variety of Standard Italian spoken in Alghero proved to be heavily affected by Sard. metaphony, hence the pronunciation of 'ferrovia' by Algh. speakers is also expected to follow typical Sard. patterns with regard to the degree of opening of mid vowels. The word was pronounced both in isolation (rows '1b' and '2b') and embedded in a longer phrase (rows '1a' and '2a'). Mean vowel durations are also provided (rightmost column).

The table shows a number of things that are worth mentioning. First, that in some specific conditions, metaphony *overwhelmed* and in other cases *did not overwhelm* the natural open-mid pronunciation of preceding mid vowels. In other words, the table contains different realisations of the same word in which it seems clear that the quality of mid vowels depends on the interaction of two opposite pressures (closing and opening), and also that the latter does not always overwhelm the former.

Secondly, various intermediate vowels were found, suggesting that in some specific cases metaphony does not proceed categorically, which is also in accordance with the results found in our corpus for unstressed vowels (see the percentage of intermediate vowel realisations in Table 26 above).

Thirdly, in both phrases the vowel immediately preceding the stressed [i] ('ferr**o**via') underwent higher metaphony effects than were seen for the more distant vowel ('f**e**rrovia'), consistently with the finding in the present study of higher percentages of jumps in AT-2 vs. AT-1 position or, in other words, a more apparent rising pressure on those unstressed vowels which are less distant from the stressed close vowel.

Fourth, the original open-mid quality of 'e' and 'o' in 'f[ɛ]rr[ɔ]' was better preserved (or restored) when the compound word was uttered in isolation. In this respect, mean vowel durations were compared for 'e' and 'o' in isolated compound words and in phrases, so as to

understand if and how duration could have played a role in affecting the quality of mid vowels. As a result, no important differences were found between the mean duration of 'o' in the two series. This suggests that the higher number of jumps in the compound words pronounced in isolation may be attributable to, for example, the greater ease with which the speaker recognises the word as a two-stem compound and reproduces the first stem 'ferro-' more similarly to the original word 'ferr[ɔ]'. By contrast, the front mid vowel 'e' did show differences in duration between the two series, and the 'longest' vowels turned out to belong to the group exhibiting fewer metaphony effects (see row 1b in the table).[215] These results are interpreted here following Canepari (2004), in that a secondary stress may help speakers to recover the acoustic features of the target vowel (i.e., [ɛ] in our example) when placed in a more controlled phonetic situation, such as in a word produced in isolation rather than in a longer speech string.

According to this view, a longer vowel duration may be considered one of the possible correlates of secondary stress, but this does not exclude the possibility that in some cases a longer duration may help mid vowels preserve their original low-mid quality even in the absence of secondary lexical stress, such as in 'P[ɛ]pina'. This hypothesis seems to provide a plausible explanation for the examples of longer jumps given in Fig. 34. Nonetheless, it raises other (unanswered) questions: if a *longer* duration can help the opening pressure resist being overcome by metaphony, why does this not normally happen for *stressed* close-mid vowels, which were seen in Fig. 34 to be much longer than their unstressed counterparts? Does it have anything to do with stressed vowels being more prominent and under greater control on the part of the speaker? Needless to say, answering these questions would require an *ad hoc* future investigation.

6.4.3.3 On the degree of vertical formant shift of longer vs. shorter jumps

Sections 6.4.3.1 and 6.4.3.2 dealt with the presence of jumps as a function of the *shorter* and *longer* duration of Sard. unstressed vowels. Some further remarks will be made here on the F1 characteristics of shorter vs. longer jumps. Do *shorter* opening jumps get closer to the new open-mid target than *longer* ones, or vice versa? Or, by contrast, can no visible differences be

[215] Mean duration values for the two sets were not reported in Ballone (2010). It should be noted that the vowel duration difference between the two series of 'e' was seen not to be dependent on the overall duration of the two sets of words, since the whole compound word 'ferrovia' presented quite similar mean duration values in the two contexts (701 ms when uttered alone and 721 ms when uttered as part of a longer phrase).

found in F1 shift between the two groups? This was not an easy question to answer, since, as seen in Fig. 34 above, in general terms jump realisations did not polarise towards two clearly separated longer vs. shorter duration clusters, but proceeded gradually over time. In order to obtain a preliminary answer to this question we selected the longest and the shortest realisations in the more crowded graph (i.e. that of Figure 34b) and measured their F1 shift[216] towards their new open-mid target. Among the longest jumps, a small set of six tokens exhibited duration values longer than 20 ms with respect to the '0' line, and were considered good candidates to represent the 'longer' category. By contrast, only one token among the shortest vowels was found to be at least 20 ms shorter than the '0' line. Hence, (the only) two vowels presenting duration values of between -10 and -20 ms were also included in this second group (three tokens in total). As a result, the three shortest vowels were found to have covered, on average, 65.3% of the distance towards their new target, while the longest ones went a bit further, reaching 75.8%.

Once again, it is advisable to treat these results with great caution, given the very low number of tokens available for the analysis. Nonetheless, the fact that longer vowels seemed to get closer to the open-mid position would support the hypothesis that jumps are not simply and not always the result of a random centralisation process, or even less so of undershoot, as much as the product of target shifts. In other words, the fact that the longer vowels got closer to the corresponding open-mid position would suggest that they had a new target (whether /ɛ/ or /ɔ/) and that they had more time to approach it.

6.4.4 Final remarks on the acoustic reduction of Sardinian unstressed mid vowels

To sum up, in §§ 6.4.1 to 6.4.3.3 two models of acoustic vowel reduction were tested and discussed in the light of experimental data obtained for Sard. mid vowels. As predicted by both the centralisation-based model (CBM) and the undershoot-based model (UBS), the unstressed vowels analysed here exhibited an overall tendency towards horizontal centralisation (see Figs. 30 and 31 above), but, in contrast with the predictions of the two models, and in accordance with the findings by Contini (1987), no clear raising was found for open-mid vowels.

[216] The two reference points to evaluate F1 shifts of jumps were constituted by the mean values of the close-mid and open-mid stressed vowels of reference. For example, if the speaker NLog_01 produced /e/ and /ɛ/ in the dent. context with a mean F1 of 400 Hz and 500 Hz, respectively, their F1 distance was calculated as 400 Hz-500 Hz=|100 Hz|. Hence, if an unstressed dent. /e/ pronounced by the same speaker as a jump had an F1 of 480 Hz, it was established that it had covered 80% of the distance (i.e. (480 Hz-400 Hz)/100*100)) towards its new target.

With regard to close-mid vowels, their frequency shift towards the central regions of the vowel space was found to be in accordance with CBM but not with UBM, since the latter normally predicts an elevation, not a lowering, of the overall vowel inventory floor.

In trying to understand why close-mid vowels presented acoustic reduction on the vertical axis and their open-mid counterparts did not, a further investigation was carried out on all the vowels which were found to be intermediate ('interm.'), and on those which were seen to have 'jumped over' their expected collocation on the vowel space to approach the area of another given phoneme ('jump'). Both jumps and intermediate vowels were found to be more present among /e, o/ than among /ɛ, ɔ/, and this fact was seen to possibly be the surface cause (or one of the main causes) of the overall lowering of unstressed /e, o/. Still, it was unclear why the latter pair of vowels exhibited an overall vertical shift whereas /ɛ, ɔ/ did not. In this respect, the variable *duration* proved not to account satisfactorily for these differences, since the two series of vowels were practically identical in duration (Table 25). For the same reason, there was still no explanation of why AT-2 vowels seemed to undergo less metaphonic pressure than their AT-1 correspondents.

In order to investigate these questions in greater depth, the analysis focused on language-dependent factors, in particular the relationship between the *opening* pressure related to the normal open-mid pronunciation of Sard. mid vowels, and the *closing* pressure activated by metaphony. From a phonological point of view, the higher instability of /e, o/ in comparison to /ɛ, ɔ/ seemed to be caused by the former pair being the result of an opposite opening vs. closing metaphonic pressure. In this respect, it has been confirmed by our data that close or close-mid vowels normally cause the preceding mid vowels to rise, but, in contrast to what is normally reported in studies concerning Sard. mid vowels, exceptions to this trend were also found in the present study (i.e. 5% of jumps and 16.6% of intermediate vowels among the 1,215 unstressed Sard. vowels analysed).

The great overall stability of open-mid Sard. unstressed vowels, which undergo horizontal centralisation but no visible vertical centralisation, has been proved on the basis of the measurements carried out in the present work and also in Contini (1987), and has been accounted for as the result of just one pressure, namely the 'natural' tendency for mid vowels to be uttered as open-mid in Sard. Yet again it is worth mentioning that such a great resistance

to vertical formant frequency shift for unstressed open-mid vowels is not predicted either by the undershoot-based model or by the centralisation-based model (see Fig. 14 above).

An important implication of these findings concerns the traditional approach to Sard. metaphony. In fact, the instrumental data gathered in the present study (and partially in Ballone, 2010) suggest that Sard. close-mid vowels should not be considered merely as the result of unidirectional metaphonic pressure, but rather as the result of two contrastive opening vs. closing pressures, even though such a contrast is not normally visible in everyday language. This more 'dynamic' approach to metaphony also provides a possible explanation of why it was possible to find jumps among both shorter than average and longer than average unstressed vowels.

In the first case, it was shown that metaphony is not as simple as some general descriptions (such as Wagner, 1941/1984:31) would suggest, and that in normal speech production speakers may have to deal not only with the more or less regular application of the rule, but also with different applications of the same rule. In this respect, the competence of the speaker and the routine use of certain words in fixed ways may be of some help in maintaining regularity in speech production. From a different perspective, however, it is not impossible for the same speaker to make miscalculations while computing or even when routinely producing mid vowels in certain conditions at a faster speech rate. In this respect, two very rare examples of jumps among stressed vowels were discussed in § 6.4.3.1 above. In that case, the miscalculation was not attributable to faster speech, but rather to the unpredicted interaction of two different models, i.e. the Italian 'archit[ˈ**ɛ**]tt[**ɔ**]' model and the Sard. 'archit[ˈ**e**]t[**u**]' model, which generated the two hybrid forms 'archit[ˈ**e**]tt[**ɔ**]' and 'archit[ˈ**ɛ**]ett[**u**]', promptly corrected by the same speaker as 'archit[ˈ**e**]tt[**u**]'. It is possible to hypothesise that similar miscalculations may also happen in Sard. normal speech in some borderline cases such as, for example, the sudden change of the final morphemes in Sard. common names during ongoing adjustments in the speech chain.[217]

[217] To mention just one among many other possible examples, if during a conversation the word [ˈb**e**n:e**ɾ**u] ('son-in-law') is mentally selected and uttered consistently with Sard. metaphony, but, after the realization of the first [ˈe], the speaker realises that it would be more correct to talk about two sons-in-law rather than just one, the final word could be uttered as something like [bˈ**e**n:ɛ**ɾ**ɔ**s**] (i.e. [#ˈbe] + initially predicted [n:**e****ɾ****u**#] + categorical shift of the latter into [n:**ɛ****ɾ****ɔ****s**#]), in violation of Sard. metaphony. The same hypothesis can also cover changes in the gender-related morpheme, since in Sard. the masculine singular morpheme is often represented by the final close vowel /u/ (i.e. [ˈb**e**ll**u**] 'handsome', 'nice'), and the correponding feminine by the final open vowel /a/ ([ˈb**ɛ**ll**a**]). Hence, if an ongoing change in the gender of the word takes place, it is not

With regard to longer jumps, § 6.4.3.2 includes an example taken from Sardinian Regional Italian (a regional variety of Standard Italian normally described in the literature as being heavily affected by Sard. metaphony[218]), in which a longer duration was seen to characterise the less metaphonised series of mid vowels. It is not clear if in that case the longer duration contributed to the preservation (or recovery) of the original open-mid quality of the unaffected vowel either *per se* or as a correlate of a secondary accent, and further studies are undoubtedly needed to deal with this and other unanswered questions raised by the present work. One fact that does seem quite clear is that when evaluating the acoustic vowel reduction in Sard., great attention should be also paid to language-dependent factors.

impossible to hypothesise the realization of such hybrid forms as [ˈb**ɛ**ll**u**](?), [ˈbell**a**](?). Yet again, it should be remembered that while such occurrences are in theory possible, they appear to be extremely rare in everyday Sard. language.

[218] See Loi-Corvetto, 1983.

Chapter 7

Conclusions and future research

The analysis of the acoustic quality of Algherese stressed vowels, discussed in § 6.2ff., seemed to confirm the great influence that Sardinian, and especially its Northern Logudorese variety, had on the language spoken in the former stronghold of the Crown of Aragon. As seen in Chapter 1, the preeminence of Sardinian in the process of reshaping Algherese Catalan (at least after the end of the fifteenth century) is not normally called into question by the majority of linguists, but, as many scholars have pointed out, it should not be forgotten that Alghero was also strongly projected towards a Mediterranean dimension, and traces of this maritime projection are still visible in the Algherese lexicon, particularly in the vocabulary of sailors and fishermen. In this respect, it could be interesting in the future to carry out a comparative analysis between Algherese vowels and those of Campanian (especially its Neapolitan and Torre del Greco varieties) and Ligurian (especially its Genoese variety), for the reasons described in Chapter 1. Another interesting acoustic comparison could be carried out in future research between Algherese and Sassarese vowels, given that, according to the archive documents analysed in § 1.5, an important part of the residents of Alghero between the first half of the nineteenth century and the first two decades of the twentieth century came from Sassari or from Sassarese-speaking areas.

With respect to the testing of two predictions of the Adaptive Dispersion Theory, these have been found not to be generally true across the nine varieties compared in this dissertation. In fact, the point-vowel area of more crowded inventories was found to be both larger and smaller than the corresponding area in less crowded inventories. For example, the seven-phoneme Campidanese and the eight-phoneme Majorcan varieties were found to occupy a larger vowel space then the five-phoneme Common Logudorese inventory, but, at the same time, they were found to be less disperse than the five-phoneme inventories of Northern Logudorese and Nuorese. With regard to the second prediction tested, this indicates that vowel phonemes should vary less in more crowded inventories than in less crowded ones. By contrast, the more crowded inventories of the Catalan varieties dealt with in the present work exhibited more variable vowels than the less crowded Sardinian inventories. Another finding which appears to challenge this ADT prediction is that, in some cases, equally crowded vowel

inventories (such as those of Northern Logudorese and Common Logudorese) exhibited different degrees of context-dependent variability.

This said, the results of the present study on the ADT predictions can be interpreted according to two different approaches.

On the one hand, it can be assumed that the Adaptive Dispersion Theory claims universal validity, hence it would be sufficient to find a few examples of vowel systems in which the ADT predictions prove not to be true in order to reject the whole theory. In this respect, our findings would reject, *in toto*, the two ADT predictions under testing.

On the other, it could be claimed that the ADT contains a possible explanation about general cross-languages tendencies, and that the only way to reliably assess (for example) if vowels tend to distribute according to general patterns consistently with their system size is to gather acoustic data from tens, if not hundreds, of vowel inventories (Becker-Kristal, 2010). In this view, the present work may constitute a contribution to the general evaluation of the theory, presenting data from a limited number of varieties (nine) and a limited (though very representative, in terms of the world's vowel inventories) range of inventory sizes (i.e. including five-, seven- and eight-vowel-phoneme systems).

Another fact worth mentioning is that if we wish to compare the size of the vowel space in different languages by comparing different acoustic research studies, special attention should also be paid to such variables as the consonantal context surrounding the target vowels. In fact, as shown in § 6.3.2ff. (see especially the formant data in Table 22 and Fig. 28), coarticulation effects can also be visible at the midpoint of stressed vowels and, as a consequence, the point-vowel area delimited by the contextual consonants flanking the target vowels may be visibly greater or smaller even in the same variety.[219] In other words, the interpretation of the differences in vowel dispersion between different languages should be done with caution if information on the consonantal context flanking the target vowels is not provided by the research studies under investigation.

[219] Among the varieties directly analysed in this dissertation, the most evident case is that of the Algherese point-vowel areas for the lab. and pal. contexts. In fact, if Heron's formula is applied to the data in Table 22, the former area is almost 1/2 bigger than the latter (271 kHz^2 and 183 kHz^2, respectively).

Another issue which calls for more attention in future research into the ADT predictions is the actual role allophones play in conditioning the vowel distribution, especially in languages such as Sardinian, in which the difference between phonemes and allophones may, in fact, not be easy to define. As seen in § 2.3 and 2.4, and further confirmed by the results shown in Chapter 6, the distribution of the vowel allophones in Logudorese and Campidanese actually tends to follow similar patterns, occupying the regions of the point vowels /i, u, a/ and the mid regions of /e, ɛ, o, ɔ/; in spite of this, and according to a synchronic and contrastive-based approach, the two systems are considered to be structurally different, since Logudorese is said to possess five contrasting vowels and Campidanese seven. As was made clear in § 2.3 and § 2.4, this structural difference only relies on a few minimal pairs, such as '[o]ru'/'[ɔ]ru', and 'b[e]ni'/'b[ɛ]ni', in the latter variety. In this respect, a reasonable question to ask is whether it is theoretically plausible for a whole set of allophones to change their distribution on the vowel space and their variability merely because, at a given moment of its history, Campidanese developed a new limited set of minimal pairs.

Complementarily, another question that was raised in the present study concerned the theoretically 'null' role allophones (namely [e, o]) should play in the distribution of the vowels in the vowel space, according to a literal interpretation of ADT. In fact, it has been seen that pentaphonemic inventories such as that of Logudorese actually present an allophonic distribution which resembles that of heptaphonemic inventories such as that of Alghere and other Catalan varieties. Not to mention the fact that the two Logudorese allophones [e, o] can be considered anything but rare.

All these facts have been reported here to suggest that, in future research into the validity of ADT predictions, it could be useful for some languages to include a reflection on the possible role allophones play in conditioning the distribution of vowel phonemes.

The third aim of the present dissertation was to evaluate the effects of acoustic vowel reduction on Sardinian unstressed mid vowels. This evaluation was carried out by using the theoretical framework of two models concerning acoustic vowel reduction: the undershoot-based model (specially in Flemming's 2005 formulation) and the centralisation-based model. The results confirmed that on the horizontal or F2 dimension unstressed Sardinian mid vowels are normally pronounced as less peripheral, consistently with both UBM and CBM. At the same time, the unstressed open-mid vowels exhibited little or no elevation, in disagreement

with both models and consistently with some findings by Contini (1987). With regard to unstressed close-mid vowels, they exhibited a tendency to be pronounced as less close than their stressed counterparts, consistently with CBM and in disagreement with UBM. At the same time, vowels in pre-pretonic position were pronounced on average as less high than the corresponding vowels in pretonic position. The possibility of some vowels exhibiting much formant frequency variability according to their position in the word structure was evaluated in Moon and Lindblom (1994); in that study, however, the more visible formant frequency shift of 'W**i**llingham' with respect to that found for 'w**i**lling' was attributed to a decrease in vowel duration, but this seemed not to be the case in our Sardinian examples, since the duration of vowels in AT-1 was found to almost equal that of vowels in AT-2. An in-depth analysis of individual vowels showed that in some cases the expected close-mid vowels were actually realised as open-mid, and this happened more frequently in AT-2 than in AT-1 position. These results suggested that in evaluating the effects of acoustic vowel reduction on Sardinian unstressed mid vowels, some language-dependent variables should be also taken into account, such as a lesser stability of Sardinian close-mid vowels due to their quality being the result of two contrasting pressures: a closing one, due to metaphony, and an opening one, due to the normal tendency for Sardinian mid-vowels to be pronounced as open-mid. In some cases the latter pressure proved not to be overcome by metaphony, and this was one of the situations in which unstressed close-mid vowels exhibited, on average, a lower realisation than their stressed counterparts. A higher percentage of exceptions to metaphony at AT-2 made these vowels, on average, even lower than the corresponding vowels at AT-1.

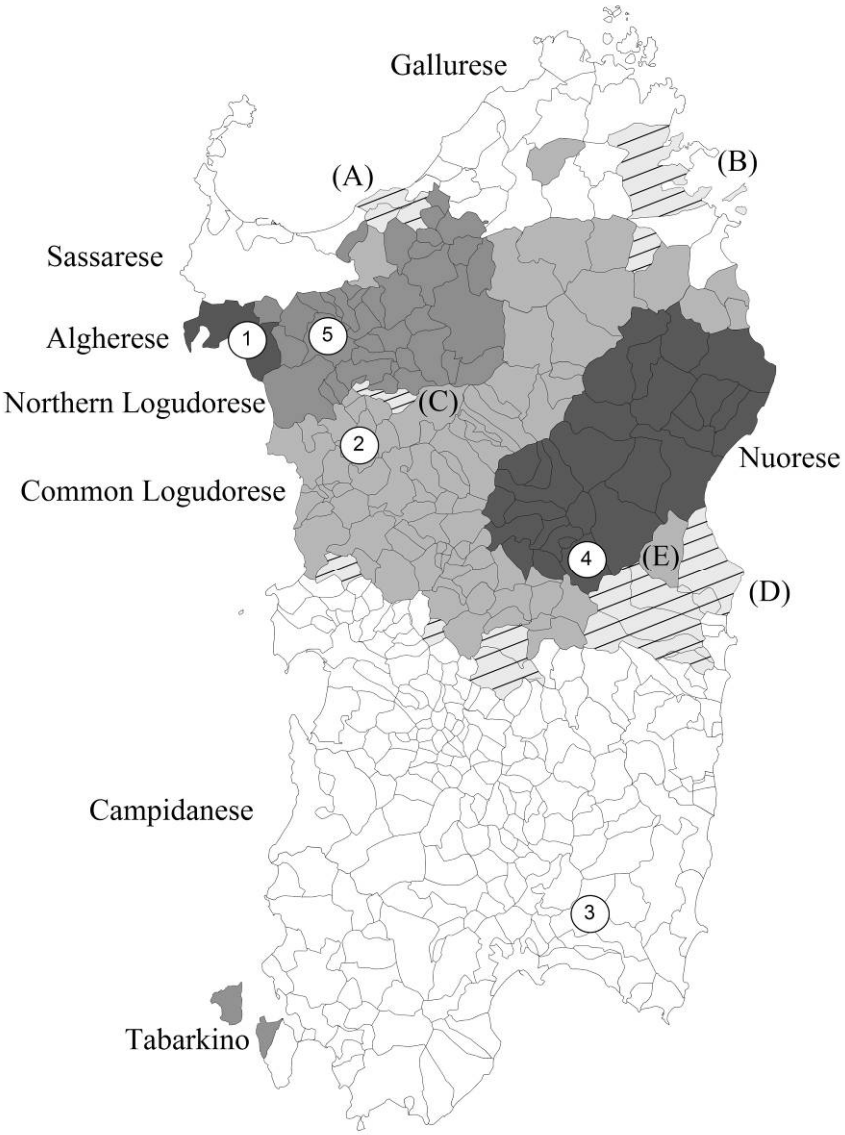
This language-based approach did not exclude the possibility of some articulatory-related variables also contributing to the conditioning of acoustic reduction. For example, the very rare examples of closing jumps (i.e. expected open-mid vowels realised as close-mid) were found to possess a much shorter duration than the corresponding non-jumps; this fact made it highly probable for formant undershoot to have played a decisive role in the production of the 'jump' vowels, since the possibility cannot be excluded that the tongue may not have had enough time to reach the ideal or target position for realising an open-mid vowel.

In future studies it could be interesting to add to the list of possible variables conditioning acoustic vowel reduction such variables as those referred to in § 6.4.3 as 'language-dependent factors'.

Appendices

Appendix I

Criteria used to prepare the linguistic map of Sardinia



The criteria used to establish boundaries for the Sardinian varieties analysed in the present work are as follows (all the mentioned tables are from Contini, 1987b, unless other sources are specified):

I: the boundary dividing Common Logudorese from Northern Logudorese has been set in accordance with table 56. In this respect, the territories belonging to the latter variety are those presenting the lateral fricative /ɬ/. Northern Logudorese has here been further divided from Sassarese (which also possesses the lateral fricative) following Table 54;

II: the boundary dividing Nuorese from Common Logudorese has been set in accordance with Table 3, and concerns the lack of voicing, in the former variety, of the intervocalic voiceless plosive /p/;

III: the boundary between Logudorese (i.e. the macro variety including Nuorese, Common Logudorese and Northern Logudorese) and Campidanese has been set in accordance with Tables 91 and 92, and concerns the raising, in the latter variety, of etymological final /ɛ, ɔ/ to /i, u/, respectively. Given the fact that only one point of investigation was chosen for Campidanese in the present work, the map does not include the traditional dialectal divisions within the Campidanese variety (for further details on this issue, see, among others, Virdis, 1978).

For the sake of simplicity, the dialectal partition was drawn along the administrative boundaries of towns/villages, even though it is more than plausible that in many territories between towns two or more different varieties can coexist. For example, the territory belonging to Alghero is presented in the map as being totally Catalan-speaking, whereas, as has been assumed throughout this dissertation, other languages (i.e. Sardinian and Sassarese) are also spoken. Another clear example of this possibility is that of Luras, a Common Logudorese-speaking town surrounded by a Gallurese-speaking area, in which Sardinian still survives as the predominant language in the urban centre, while the surrounding area is predominantly Gallurese-speaking (Maxia, 2009:37).

In the linguistic map above, four ‘grey zones’ are also shown, i.e. areas in which a clear dialectal division was not possible on the basis of the isoglosses chosen to draw the map, or (as in the case of Olbia), where two different varieties coexist in a demographically comparable way. These grey zones are graphically highlighted by oblique lines and indicated by the capital letters (A), (B), (C), (D).

Grey zone (A) includes towns which are said to possess linguistic features of both Sassarese and Gallurese varieties (i.e. two Corsican-based dialects spoken in Northern Sardinia). The towns belonging to (A) are Castelsardo, Sedini and Tergu (Maxia, 2009:37).

Grey zone (B) corresponds to the town of Olbia and its territory. Differently from (A), this area does not include a variety featuring elements of different dialects, as much as two coexisting languages, i.e. Sardinian (in its Common Logudorese variety) and Gallurese. In other Sardinian towns and cities, too, the historical language coexists with one (or more) other Sardinian varieties and/or with an alloglot language present on the island. For example, in Oppo et al. (2007) (see especially tables 8.2 and 8.3), half of the interviewees (50.0%) living in Alghero declared an active competence in Algherese Catalan, but, at the same time, a non-negligible percentage of subjects declared an active competence in Sardinian (23.2%). As regards Olbia, the percentage of people declaring an active competence in Gallurese (which is the L1 of many recent immigrants) was 39.9%, a figure that is almost as high as that of people declaring an active competence in Sardinian, i.e. 44.6% (see Oppo et al. 2007, tables 8.2 and 8.3). That is why Olbia and its territory have been included here in a grey zone.

Grey zone (C) includes the town of Giave, which is described in Table 56 as presenting the word 'custu' ('this') with both the Common Logudorese consonantal cluster [st] and the Northern Logudorese correspondent [ʂt].

Grey zone (D) includes a series of varieties situated in a central belt between Logudorese and Campidanese, and which present vowel features of both systems, according to Tables 91 and 92. The data by Contini[220] were then compared to those shown in the impressionistic study by Loporcaro (2011). The two studies present differences in the interpretation (and sometimes even in the description) of the way Campidanese vowel reduction affects the varieties of the grey zone, but what is relevant for the preparing of the map above is that the two studies almost coincide in listing the towns belonging in this grey zone: Seneghe, Allai, Meana, Laconi, Villagrande, Arzana, Elini, Ilbono, Talana, Triei, Baunei. In this respect, the only difference between the two works is that Contini's study also includes the dialect of Urzulei in the grey zone, since it presents some words affected by Campidanese vowel reduction. Loporcaro, by contrast, still defines this variety as Logudorese, since the '-i' ending words of

[220] It should be mentioned that Contini does not use the term 'grey zone' but, rather, 'situation transitoire' (1987:443).

the latter variety are considered by this author as mere loans from Campidanese, and do not affect the variety in question on a structural level, where 'structural' refers to such morphemes as the one indicating the infinitive of the verbs (/ɛ/), or the one indicating the first person singular of verbs (/ɔ/), which are still Logudorese. In preparing the linguistic map for this study, this last criterion was used to define the variety of Urzulei as still being Logudorese.

Appendix II

Original version, in Catalan, of Table 1 (taken from Veny, 1982/2002:19–20)

Català oriental	*Català occidental*
A. FONÈTICA HISTÒRICA	
1. Confusió A, E àtones en [ę]; PATER > *parę*; CASA > *casę*.	1. Distinció A, E àtones PATER > *parę*; CASA > *casa* (o *casę*)
2. Neutralització de O, U àtones en [u]: *pusar,* posar, *suar.*	2. Distinció de O, U àtones: *posar, suar.*
3. E tancada llat. vg. > /ẹ/: CEPA> *cẹba.*	3. E tancada llat. vg. > /ẹ/: CEPA> *cẹba.*
4. La Ŭ breu de IŬNCU passa a *o: jonc.*	4. La Ŭ breu de IŬNCU passa a *u: junc, jum.*
5. GUÁ-, QUÁ- tònics tendeixen a *kó- gó: cotre,* quatre; *gotlla,* guatlla.	5. QUÁ-, GUÁ- tònics solen mantenir-se: *quatre, guatlla (guala).*
6. -GUA (o -QUA) final tendeix a evolucionar a -gę (o -kę): *aigua > aigę, llengua > llengę.*	6. -GUA (o -QUA) final sol mantenir-se: *aigua, llengua.*
7. LY, C'L, G'L llatvg. > y, i̯: PALEA > *paia,* OC'LU > *ui.*	7. LY, C'L, G'L llatvg. > l̯: *palla, ull.*
8. /š/ fricativa inicial o postconsonàntica: *xinxa, panxa.*	8. /s̑/ africada inicial o postconsonàntica: *txintxa, pantxa.*
9. /š/ intervocàlica o final no precedida de iod: *caixa* /kášę/, *coix* /kǫ́š/.	9. /š/ intervocàlica o final no precedida de iod > (iš): *caixa* /kái̯ša/, *coix* /kǫi̯š/.
10. Reforçament dental de mots acabats en -r: *cort,* cor, *cart,* car.	10. Manca d'aquest reforçament dental: *cor, car.*
11. Manca de nasal adventícia a *llagost (llagosta,* o *llagostí).*	11. Nasal adventícia a *llangost (llangosta,* o *llangostí).*
12. HEDERA > *heura.*	12. HEDERA > *hedra.*
B. MORFOLOGIA	
13. Plurals d'antics proparoxítons acabats en *n* perden la nasal: *home/homes.*	13. Plurals d'antics proparoxítons acabats en *n* mantenen la nasal: *home/hòmens.*
14. Desinència *-u, -i* o Ø a la pers. 1 de l'IP: *cantu, canti, cant,* canto.	14. Desinència *-o,* o *-e* a la pers. 1 de l'IP: *canto, cante.*
15. Formes reforçades o reduïdes dels pronoms personals febles: *em, ens, et, us, el, els, en.*	15. Formes plenes dels pronoms personals febles: *me, mos, te, vos, se (lo), (los), ne.*
16. Desinència dels verbs incoatius a l'IP i SP (pers. 1, 2, 3, 6) i a l'Imperatiu (pers. 2) amb *-é-*: *serveix, serveixi, servesca.*	16. Desinència dels verbs incoatius a l'IP i SP (pers. 1, 2, 3, 6) i a l'Imperatiu (pers. 2) amb *-í-*: *servix, servisca, servixa.*
17. Desinències del SP en 1 *-i,* 2 *-is,* 3 *-i,* 6 *-in: canti, cantis,* etc.	17. Desinències del SP 1 *-a,* 2 *-es,* 3 *-e,* 6 *-en* (i variants)*: canta, cantes,* etc.
C. LÈXIC	
18. Lèxic específic: a) *mirall*; b) *noi*; c) *llombrígol*; d) *xai, be.*	18. Lèxic específic: a) *espill*; b) *xic*; c) *melic*; d) *corder.*

Appendix III

List of the towns, districts and baronies enfeoffed to Alghero between 1596 and 1737, according to A.S.C.A.: 3.9.2 *Scrutinio del grano ville infeudate* - 1596/1737. The correspondent Sardinian variety is given in square brackets.

Alà	[CLog.]	district of Costa de Valls	[CLog.]	Orani	[Nuor.]
Anela	[CLog.]	Dualchi	[CLog.]	Orotelli	[Nuor.]
Ardara	[NLog.]	Esporlatu	[CLog.]	Orune	[Nuor.]
Banari	[NLog.]	Florinas	[NLog.]	Osidda	[CLog.]
Benetutti	[CLog.]	towns of Goceano	[CLog.]	Osilo	[CLog.]
Berchidda	[CLog.]	Illorai	[CLog.]	Ossi	[NLog.]
Bessude	[NLog.]	Ittiri Cannedu	[NLog.]	Ottana	[Nuor.]
Birori	[CLog.]	Ittiri Fustiarbus	[NLog.]	Ozieri	[NLog.]
district of Bitti	[Nuor.]	Laerru	[NLog.]	barony of Paulis	[NLog.]
Bolotana	[CLog.]	Lei	[CLog.]	Pattada	[CLog.]
Bonnannaro	[NLog.]	district of Macomer	[CLog.]	Perfugas	[NLog.]
Bono	[CLog.]	Mara	[CLog.]	Ploaghe	[NLog.]
district of Bonorva	[CLog.]	Martis	[NLog.]	Rebeccu	[CLog.]
Borore	[CLog.]	district of Monteacuto	[CLog.]	Romana	[NLog.]
Bortigali	[CLog.]	Monteleone	[NLog.]	Sarule	[Nuor.]
Bortigiadas	[Gall.]	Barony of Monteleone	[NLog.]	Sedilo	[CLog.]
Borutta	[NLog.]	Mores	[NLog.]	Semestene	[CLog.]
Bottida	[CLog.]	Noragugume	[CLog.]	Sennori	[NLog.]
Buddusò	[CLog.]	Nughedu	[NLog.]	Silanus	[CLog.]
Bulzi	[NLog.]	Nule	[CLog.]	Siligo	[NLog.]
Bultei	[CLog.]	Nulvi	[NLog.]	Sorso	[Sass.]
Cargeghe	[NLog.]	Nuoro	[Nuor.]	Torralba	[NLog.]
Cheremule	[NLog.]	district of Nuoro	[Nuor.]	Tissi	[NLog.]
Chiaramonti	[NLog.]	Oniferi	[Nuor.]	Tula	[NLog.]
Codrongianos	[NLog.]	Barony of Oppia	[NLog.]	Uri	[NLog.]
Barony of Anglona	[NLog.] [Sass.] [Gall.]	Villanova Monteleone	[NLog.]	Usini	[NLog.]
		Barony of Cabuabbas and Thiesi	[CLog.]/ [NLog.]	Sedini	[Sass.] [Gall.]
Barony of Meilogu	[NLog.] [CLog.]	Barony of Romangia	[Sass.] [NLog.]	Barony of Padria and Pozzomaggiore	[CLog.]
Giave e Cossoine	[NLog.] [CLog.]	Barony of Monte Muros	[NLog.]	Furtei and Marquisate of Terralba	[Camp.]

Appendix IV

Unnormalised F1, F2, F3 frequency values for Algherese and Sardinian vowels. Mean data have been computed across repetitions as a function of vowel, speaker and dialect.

		Algh.				CLog.				Camp.				Nuor.				NLog.		
		F1	*F2*	*F3*		*F1*	*F2*	*F3*		*F1*	*F2*	*F3*		*F1*	*F2*	*F3*		*F1*	*F2*	*F3*
i	01_PS	340	2286	2817	01_MM	331	2015	2452	01_NC	338	2153	3027	01_BP	334	2168	2650	01_GC	363	2224	2723
e		433	2188	2769		428	1869	2386		425	2038	2613		401	2100	2608		430	1955	2464
ɛ		536	1929	2624		513	1679	2326		550	1807	2518		532	1865	2561		527	1754	2432
a		803	1462	2569		671	1297	2321		770	1341	2152		790	1348	2743		721	1268	2498
ɔ		524	1042	2733		505	1022	2216		511	1016	2394		538	1042	2520		521	1044	2468
o		446	992	2698		411	1022	2141		433	966	2324		409	975	2601		439	996	2562
u		353	986	2544		341	993	2185		334	856	2302		334	929	2500		357	957	2456
i	02_SM	350	1950	2506	02_FF	307	2022	2540	02_LA	390	2127	2851	02_FD	366	2120	2720	02_GBS	343	2056	2661
e		441	1825	2471		410	1797	2376		478	1983	2597		450	2059	2704		435	1858	2426
ɛ		556	1671	2467		495	1616	2320		584	1795	2531		585	1905	2565		515	1737	2433
a		653	1217	2482		644	1260	2190		771	1397	2337		818	1410	2405		695	1305	2273
ɔ		537	1017	2485		469	970	2258		558	1050	2214		575	1074	2458		483	1026	2354
o		451	953	2454		392	950	2235		482	1030	2447		478	1032	2489		415	939	2362
u		353	885	2253		318	929	2098		401	933	2399		387	937	2370		347	869	2380
i	03_PB	360	2180	2740	03_TC	331	2062	2620	03_BM	357	2136	2741	03_BS	337	2046	2708	03_GBD	377	2167	2674
e		431	2050	2642		418	1987	2667		464	1983	2515		430	2016	2578		445	1969	2470
ɛ		566	1818	2479		611	1793	2604		551	1841	2500		576	1838	2445		559	1885	2568
a		773	1393	2320		700	1418	2395		727	1359	2390		783	1391	2316		763	1416	2398
ɔ		541	965	2260		582	1070	2394		523	1016	2486		570	1130	2220		575	1106	2428
o		440	923	2305		421	998	2444		462	996	2528		451	1108	2216		447	1027	2394
u		357	903	2323		341	972	2316		382	926	2490		383	1027	2196		360	889	2390
i	04_SS	355	2185	2719	04_BC	390	2100	2690	04_AP	327	2030	2619	04_BSe	331	2111	2805	04_SM	337	2315	2994
e		460	2008	2612		455	1937	2429		428	1835	2412		411	2098	2762		415	2106	2617
ɛ		574	1803	2547		592	1783	2474		508	1713	2375		548	2006	2634		526	1959	2560
a		769	1331	2645		766	1389	2436		744	1277	2384		789	1351	2554		777	1319	2550
ɔ		560	998	2658		578	1120	2360		506	984	2503		548	1043	2444		485	969	2692
o		450	943	2735		439	1052	2325		436	975	2458		429	940	2308		410	909	2692
u		373	912	2539		373	987	2248		340	905	2378		340	901	2226		342	855	2612
i	05_AC	334	2145	2559	05_SP	363	2131	2707	05_MM	345	2243	2692	05_FL	355	2143	2820	05_TC	357	2106	2621
e		421	2001	2492		417	1878	2517		441	1949	2451		421	2060	2530		399	1993	2487
ɛ		546	1768	2472		560	1677	2504		564	1887	2594		565	1955	2509		506	1856	2430
a		689	1364	2426		738	1303	2422		756	1358	2733		851	1369	2435		779	1318	2424
ɔ		531	1075	2410		531	1045	2235		551	1030	2698		558	1019	2279		566	1016	2553
o		443	999	2434		426	1039	2302		447	998	2684		411	941	2291		422	928	2378
u		363	992	2404		369	993	2202		391	969	2592		358	877	2231		358	887	2352

Appendix V

Normalised (CLIH) F1, F2, F3 frequency values for Algherese and Sardinian vowels. Mean data have been computed across repetitions as a function of vowel, speaker and dialect.

		Algh.			CLog.			Camp.			Nuor.			NLog.		
		F1	*F2*	*F3*	*F1*	*F2*	*F3*	*F1*	*F2*	*F3*	*F1*	*F2*	*F3*	*F1*	*F2*	*F3*
i	01	-0.328	0.446	0.051	-0.296	0.395	0.069	-0.311	0.454	0.206	-0.312	0.434	0.020	-0.251	0.476	0.080
e		-0.087	0.402	0.034	-0.038	0.320	0.042	-0.083	0.399	0.059	-0.131	0.402	0.004	-0.083	0.347	-0.020
ɛ		0.127	0.276	-0.020	0.143	0.213	0.017	0.174	0.279	0.022	0.153	0.283	-0.014	0.121	0.238	-0.033
a		0.531	-0.001	-0.041	0.410	-0.046	0.014	0.510	-0.019	-0.135	0.548	-0.041	0.055	0.434	-0.086	-0.006
ɔ		0.104	-0.340	0.021	0.126	-0.284	-0.032	0.101	-0.297	-0.028	0.165	-0.298	-0.030	0.109	-0.280	-0.018
o		-0.056	-0.389	0.008	-0.078	-0.284	-0.066	-0.065	-0.347	-0.058	-0.111	-0.366	0.002	-0.062	-0.327	0.019
u		-0.291	-0.395	-0.051	-0.266	-0.313	-0.046	-0.325	-0.468	-0.067	-0.312	-0.414	-0.038	-0.268	-0.367	-0.023
i	02	-0.287	0.407	0.025	-0.316	0.440	0.106	-0.269	0.416	0.141	-0.321	0.394	0.074	-0.271	0.437	0.099
e		-0.056	0.341	0.011	-0.028	0.322	0.039	-0.065	0.347	0.048	-0.115	0.365	0.068	-0.033	0.337	0.006
ɛ		0.176	0.252	0.009	0.162	0.216	0.016	0.134	0.247	0.022	0.147	0.288	0.015	0.135	0.269	0.010
a		0.336	-0.064	0.015	0.424	-0.033	-0.042	0.412	-0.004	-0.057	0.482	-0.014	-0.049	0.435	-0.017	-0.059
ɔ		0.141	-0.244	0.017	0.108	-0.294	-0.012	0.089	-0.289	-0.111	0.129	-0.285	-0.028	0.072	-0.257	-0.023
o		-0.033	-0.309	0.004	-0.071	-0.315	-0.022	-0.059	-0.309	-0.012	-0.055	-0.326	-0.015	-0.080	-0.346	-0.020
u		-0.277	-0.383	-0.082	-0.281	-0.337	-0.085	-0.242	-0.408	-0.031	-0.266	-0.422	-0.064	-0.259	-0.423	-0.013
i	03	-0.285	0.464	0.119	-0.346	0.384	0.052	-0.302	0.431	0.084	-0.367	0.344	0.131	-0.257	0.425	0.078
e		-0.105	0.402	0.082	-0.115	0.347	0.069	-0.040	0.357	-0.002	-0.123	0.329	0.082	-0.093	0.329	-0.001
ɛ		0.168	0.282	0.019	0.266	0.244	0.046	0.133	0.283	-0.008	0.169	0.236	0.029	0.134	0.285	0.038
a		0.478	0.016	-0.047	0.402	0.009	-0.038	0.409	-0.022	-0.053	0.476	-0.042	-0.026	0.447	-0.001	-0.031
ɔ		0.122	-0.352	-0.073	0.217	-0.273	-0.039	0.080	-0.313	-0.013	0.159	-0.250	-0.068	0.163	-0.248	-0.018
o		-0.085	-0.396	-0.054	-0.106	-0.342	-0.018	-0.044	-0.332	0.004	-0.075	-0.270	-0.069	-0.088	-0.322	-0.032
u		-0.293	-0.417	-0.046	-0.317	-0.369	-0.072	-0.236	-0.405	-0.012	-0.239	-0.346	-0.079	-0.305	-0.467	-0.034
i	04	-0.323	0.467	0.031	-0.245	0.391	0.106	-0.328	0.429	0.068	-0.340	0.410	0.105	-0.296	0.518	0.114
e		-0.063	0.383	-0.009	-0.091	0.310	0.004	-0.058	0.327	-0.014	-0.124	0.404	0.090	-0.086	0.423	-0.020
ɛ		0.158	0.275	-0.034	0.173	0.227	0.022	0.113	0.259	-0.029	0.165	0.359	0.042	0.150	0.351	-0.042
a		0.451	-0.028	0.003	0.431	-0.023	0.007	0.494	-0.035	-0.026	0.529	-0.037	0.011	0.541	-0.045	-0.046
ɔ		0.133	-0.316	0.009	0.148	-0.238	-0.025	0.109	-0.295	0.023	0.165	-0.295	-0.033	0.069	-0.353	0.008
o		-0.085	-0.373	0.037	-0.127	-0.301	-0.040	-0.041	-0.305	0.005	-0.081	-0.399	-0.090	-0.098	-0.416	0.008
u		-0.272	-0.407	-0.037	-0.290	-0.365	-0.074	-0.290	-0.380	-0.028	-0.314	-0.442	-0.126	-0.281	-0.478	-0.022
i	05	-0.324	0.420	0.041	-0.264	0.436	0.118	-0.342	0.463	-0.342	-0.303	0.434	0.147	-0.268	0.438	0.063
e		-0.094	0.350	0.015	-0.124	0.310	0.045	-0.096	0.323	-0.096	-0.132	0.395	0.038	-0.157	0.382	0.010
ɛ		0.166	0.227	0.006	0.170	0.197	0.040	0.149	0.290	0.149	0.162	0.342	0.030	0.082	0.311	-0.013
a		0.398	-0.032	-0.012	0.447	-0.056	0.006	0.442	-0.039	0.442	0.572	-0.014	0.000	0.513	-0.031	-0.015
ɔ		0.138	-0.270	-0.019	0.118	-0.277	-0.074	0.126	-0.315	0.126	0.150	-0.309	-0.066	0.193	-0.291	0.036
o		-0.042	-0.344	-0.009	-0.102	-0.283	-0.045	-0.061	-0.347	-0.061	-0.156	-0.389	-0.061	-0.101	-0.382	-0.035
u		-0.242	-0.351	-0.022	-0.246	-0.327	-0.089	-0.218	-0.376	-0.218	-0.294	-0.460	-0.088	-0.263	-0.426	-0.046

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