Articulatory, positional and coarticulatory characteristics for clear /l/ and dark /l/: evidence from two Catalan dialects

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Electropalatographic and acoustic data reported in this study show differences in closure location and degree, dorsopalatal contact size, closure duration, relative timing of events and formant frequency between clear /l/ and dark /l/ in two dialects of Catalan (Valencian and Majorcan). The two Catalan dialects under investigation differ also regarding degree of darkness but essentially not regarding coarticulatory resistance at the word edges, i.e. the alveolar lateral is equally dark word-initially and word-finally in Majorcan, and clearer in the former position vs. than the latter in Valencian, and more resistant to vowel effects in the two positions than intervocalically in both dialects. With reference to data from the literature, it appears that languages and dialects may differ as to whether /l/ is dark or clear in all word positions or whether or not initial /l/ is clearer than final /l/, and that articulatory strengthening occurs not only word- and utterance-initially but word- and utterance-finally as well. These and other considerations confirm the hypothesis that degree of darkness in /l/ proceeds gradually rather than categorically from one language to another.

1 Introduction

This paper seeks to improve our knowledge of the articulatory properties of speech sounds through the study of differences in their phonetic implementation as a function of dialect, speaker and position. It reports articulatory and acoustic data on the (co)articulatory characteristics of /l/ in two dialects of Catalan where the consonant is known to be dark (Majorcan) or clear (Valencian[1]). Several issues are investigated in the light of experimental evidence for the alveolar lateral in other languages and dialects, for example, whether the degree of darkness in /l/ proceeds categorically or gradually across dialects, and what

[1] Catalan is a Romance language spoken in the Northeastern Spanish region of Catalonia, as well as in the southern Valencian region, and in Majorca and the other Balearic islands since the turn of the 13th century. Majorcan is spoken by about 500,000 speakers and Valencian by about two million people. Specific features of Majorcan are the presence of /ə/ in stressed position (which was probably inherited from the Old Catalan vowel system) and of palatal stop allophones of /k, g/ before front vowels and word-finally (probably an autochthonous development). Several phonetic characteristics of Valencian have been attributed to Spanish influence, i.e. syllable-final stop lenition and the absence of voiced fricatives and affricates in some geographical areas.

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articulatory mechanisms are used by speakers for producing dark and clear varieties of /l/ in different vowel contexts and positions.

1.1 Darkness in /l/ as a continuum

Phonetic classifications group languages and dialects into two classes depending on whether they exhibit a dark (also velarized or pharyngealized) or a clear (also non-velarized or non-pharyngealized) variety of /l/. These two consonant types may be characterized by the presence or absence of a postdorsal constriction at the velar or upper pharyngeal region and of considerable predorsum lowering, respectively (Narayanan, Alwan & Haker 1997). On the basis of these tongue configurations they have been assigned two different gestural specifications within the Articulatory Phonology framework, i.e. an apical raising and a postdorsum retraction gestures (dark /l/), and a single tongue tip raising gesture (clear /l/) (Browman & Goldstein 1995).

Recent cross-language electropalatographic (EPG) and acoustic data suggest, however, that darkness ought to be considered a gradual phonetic property, rather than a categorical attribute. According to this view, there is a dialect-specific continuum proceeding from strongly dark to very clear varieties of /l/ through consonant realizations exhibiting intermediate degrees of darkness (Recasens, Fontdevila & Pallarès 1995). Moreover, as discussed below, this scalar progression would apply to dialects in which both /l/ types occur as positional allophones as well as to dialects preferring one of the two categories over the other irrespective of syllable position.

Evidence for the gradualness hypothesis presented next derives from data for Qp or quotient of dorsopalatal contact (which reflects the degree of dorsal contact at the palatal zone; see section 2, 'Method', below) and for F2 (which is positively correlated with Qp) for /ili/, /ala/ and /ulu/ in several languages and dialects. The F2 data of interest, together with the relevant bibliographical references, are presented in table 1. Qp data have been taken from Recasens (2004a) and are not reported in the table.

Data for /ili/ reveal the existence of dialect-dependent differences in Qp and F2 for both dark /l/ and clear /l/. Values for dark /l/ are lower in Majorcan Catalan (Qp = 0.18, F2 = 1229 Hz) and American English (F2 = 1170 Hz) than in Eastern Catalan (Qp = 0.21, F2 = 1450 Hz or 1349 Hz). In addition, British English dialects may differ regarding degree of darkness, i.e. the alveolar lateral appears to be darker in Leeds British English than in Newcastle British English, as suggested by F2 amounting to 1024 Hz in the former and to 1359 Hz in the latter. On the other hand, clear /l/ in Valencian Catalan (Qp = 0.44, F2 = 1982 Hz) appears to be clearer than clear /l/ in German[2] (Qp = 0.37, F2 = 1681 Hz or 1820 Hz) and as clear as clear /l/ in Spanish, Italian and French (F2 usually above 1800 Hz).

Articulatory and acoustic values for /l/ in the sequence /ala/ happen to be similar in dialects and languages exhibiting a dark variety of the consonant, i.e. Majorcan Catalan (Qp = 0.03, F2 = 1084 Hz), Eastern Catalan (Qp = 0.03, F2 = 1150 Hz or 1065 Hz) and American English (F2 = 1000 Hz). Sound systems with a clear variety of /l/ may exhibit dissimilar values however, i.e. lower in Valencian Catalan (Qp = 0.06, F2 = 1165 Hz) than in German (Qp = 0.04, F2 = 1363 Hz or 1550 Hz), Spanish (F2 = 1216 Hz, 1400 Hz or 1500 Hz), Italian (F2 = 1500 Hz) and French (F2 = 1330 Hz).

The existence of dialectal realizations of /l/ with formant values which are neither appropriate for the dark variety or for the clear variety renders a binary feature approach problematic. This appears to be the case for F2 values for /ili/ much above a typical 1000 Hz frequency for dark /l/ (see the data for Eastern Catalan and Newcastle British English presented

[2] This is so for Standard German and several German dialects. Data reported in Recasens et al. (1995) were collected from speakers born in dialectal areas known to have clear /l/, i.e. Swabia and Bavaria. The German subjects in Chafcouloff (1972) spoke High German.

Table 1 F2 frequency and mean coarticulatory distance (MCD) values for dark /l/ and clear /l/ in several languages and dialects ordered alphabetically. Data are given for the word initial (#__), intervocalic (V__V) and word final (__#) positions in the three vowel contexts /i, a, u/. The table also reports the bibliographical references where the data have been taken from, as well as the number of speakers within parentheses (males only).

		/i/	/a/	/u/	MCD	
Clear /l/						
Catalan (Valencian)	(V_V)	1982	1165		***408***	see figure 4b (5)
French	(#_)	1682	1524	1365	***79***	Chafcouloff 1985 (6)
	(V_V)	1830	1330	1270	***250***	Chafcouloff 1985 (6)
	(_#)	1747	1512	1102	***118***	Chafcouloff 1985 (6)
German	(V_V)	1681	1363		***159***	Recasens et al. 1995 (4)
	(V_V)	1820	1550	1370	***135***	Chafcouloff 1972 (3)
Italian	(V_V)	1908	1500		***204***	Bladon & Carbonaro 1978 (2)
Spanish	(#_)	1800	1560	1400	***120***	Quilis et al. 1979 (7)
	(V_V)	1630	1500	1420	***65***	Quilis et al. 1979 (7)
	(V_V)	2195	1216		***490***	Recasens 1987 (2)
	(V_V)	1850	1400	1300	***225***	Chafcouloff 1972 (3)
	(_#)	1960	1520	1410	***220***	Quilis et al. 1979 (7)
Dark /l/						
Catalan (Eastern)	(#_)	1250	1000	1050	***125***	Recasens 1986 (6)
	(V_V)	1450	1150	1000	***150***	Recasens 1986 (6)
	(V_V)	1349	1065		***142***	Recasens et al. 1995 (5)
	(_#)	1000	1000	850	***0***	Recasens 1986 (6)
Catalan (Majorcan)	(V_V)	1229	1084		***73***	see figure 4a (5)
English (American)	(#_)	1185	900	1070	***142***	Lehiste 1964 (5)
	(V_V)	1170	1000	1000	***85***	Chafcouloff 1972 (3)
	(_#)	740	870	655	***65***	Lehiste 1964 (5)
English (British RP)	(#_)	1600	1120	1360	***240***	Bladon & Al-Bamerni 1976 (4)
	(_ #)	1000	860	700	***70***	Bladon & Al-Bamerni 1976 (4)
English (Leeds British)	(#_)	1012				Local & Carter 2002 (4)
	(V_V)	1024				
	(_#)	1024				
English (Newcastle British)	(#_)	1588				Local & Carter 2002 (4)
	(V_V)	1359				
	(_#)	1140				
Portuguese (European)	(#_)	924	858		***33***	Andrade 1999 (2)
Russian	(#_)		850			Fant 1960: 167 (1)
	(#_)		750			Bolla 1981 (1)

above) and below a typical 2000 Hz frequency for clear /l/ (in German), and for F2 values for /ala/ much below a typical 1500 Hz frequency for clear /l/ (in Valencian Catalan).

Moreover, this scenario casts into doubt the validity of the complex, two-gestural status of dark /l/ (Sproat & Fujimura 1993, Browman & Goldstein 1995). A gradual progression from clear /l/ to dark /l/ suggests that these two varieties of the alveolar lateral may be produced instead with a single gesture and different degrees of predorsum lowering and postdorsum retraction. If so, front dorsum lowering could be associated with laterality itself rather than with active tongue dorsum lowering and backing, and would definitely be enhanced during the production of dark /l/.

Assuming that dialectal varieties of /l/ differ in degree of darkness in a non-categorical manner, the issue is the extent to which those varieties may be set in contrast when their articulatory, positional and contextual attributes are taken into consideration. The present study addresses this issue through an analysis of articulatory and acoustic data for dark /l/ in Majorcan and for clear /l/ in Valencian according to several speakers of these two Catalan dialects, and through a comparison between these data and those for dark /l/ and clear /l/ in other languages and dialects reported in the literature.

1.2 Articulation

In addition to the degree of dorsopalatal contact, phonetic realizations of /l/ varying in degree of darkness may differ with respect to tongue fronting at the place of articulation, the implementation of a closure or constriction, and variations in the relative timing of events such as voicing, apical closure and tongue dorsum lowering and retraction.

1.2.1 Place of articulation

EPG data suggest that the alveolar closure for dark /l/ in New York City American English is more anterior, less extended and less variable than that for clear /l/ in Italian (Recasens & Farnetani 1990). In agreement with those data, dark /l/ appears to be dentoalveolar in Albanian, Breton, Russian (Straka 1968, Ladefoged & Maddieson 1996: 186f.) and American English and other English varieties (Giles & Moll 1975, Browman & Goldstein 1995), while clear /l/ has been reported to be plain alveolar in Parisian French (Dart 1991). A relationship between dentality and darkness, and alveolarity and clarity is not restricted to laterals but applies to other coronal consonants, i.e. to pharyngealized vs. non-pharyngealized consonants in Arabic (Al-Ani 1970) and to velarized vs. palatalized consonants in Russian and other Slavic languages (Koneczna & Zawadowski 1956).

These differences in closure fronting may be related to differences in tongue body configuration such that more anterior closures contribute more effectively than more retracted closures to velarization or pharyngealization. This is not to say, however, that the tongue body configuration for dark /l/ may not be achieved in other ways, i.e. curling the tongue tip at the alveolar zone in American English (Delattre 1965: 88f., Straka 1968).

Data on the tongue articulator(s) involved in the production of dentals and alveolars reveal that speakers prefer to use the tongue tip to the tongue blade for /l/ while the opposite may be true of /t, d, n, s, z/ (see evidence for French and English in Dart 1991). Therefore, the term APICAL will often be assigned to the front tongue region participating in closure formation for /l/.

1.2.2 Vocalized realizations

In comparison to clear /l/, dark /l/ may lack a central closure. Instances of vocalization have been found to occur for dark /l/ syllable-finally, whether before another consonant or before a pause in British English and American English (Giles & Moll 1975, Scobbie & Wrench 2003) and in Brazilian Portuguese (Feldman 1972). The presence of lingual contact at the sides rather than at the center of the alveolar zone for vocalized realizations of /l/ (Hardcastle & Barry 1985) suggests that /l/ vocalization is achieved through articulatory reduction. The process in question has also been attributed to perceptual confusion between the grave acoustic spectra for dark /l/ and for /w/ (Ohala 1974).

1.2.3 Temporal organization

Clear and dark varieties of /l/ are also expected to differ regarding their articulatory trajectories over time. In contrast with clear /l/, tongue dorsum lowering precedes tongue tip raising for the implementation of dark /l/ (Sproat & Fujimura 1993). In utterance-final position, this mismatch increases in such a way that apical closure may begin after voicing has resumed for dark /l/ in American English, while tongue tip activity and tongue dorsum activity occur synchronously for clear /l/ in Italian (Recasens & Farnetani 1994). Moreover, these differences in temporal organization cause the period of articulatory closure to be longer for dark /l/ than for clear /l/, and the period of acoustic closure to show the opposite relationship.

Types of /l/ specified for intermediate degrees of darkness ought to exhibit an intermediate behavior with respect to the articulatory characteristics referred to in the present section (1.2) so far. Some support for this expected pattern comes from EPG data for moderately dark /l/ in Eastern Catalan. Thus, the fact that Eastern Catalan /l/ is less dark than American English /l/ could explain why it does not undergo vocalization, may be plain alveolar rather than dentoalveolar syllable-initially, and is implemented partly but not entirely after voicing has ceased in utterance-final position (Recasens & Farnetani 1990, Recasens & Pallarès 2001). Eastern Catalan /l/ appears to have been darker in the beginning of the 20th century, given palatographic data showing that it was produced with a dentoalveolar closure, involved no dorsopalatal contact and could undergo vocalization (Barnils 1933).

The hypothesis that dialects may differ regarding place of articulation, frequency of vocalization and spatiotemporal organization of the alveolar lateral depending on whether they exhibit a dark or a clear variety of /l/ will be tested on data from Majorcan and Valencian. Our prediction is that Majorcan should resemble American English in this respect given that /l/ is strongly dark in both dialects. On the other hand, clear /l/ in Valencian should behave like clear /l/ in Italian or French though perhaps less so than expected judging from the low F2 frequency for the alveolar lateral in the sequence /ala/ in the Catalan dialect (see section 1.1 above). Attention will be paid to dialect-dependent differences in relative timing between voicing and apical closure not only utterance-finally but also utterance-initially, the prediction being that closure is prone to be partly or entirely voiceless for dark /l/ and fully voiced for clear /l/.

1.3 Positional allophones

The present paper is also concerned with the extent to which degree of darkness changes with position, and with whether syllable-initial and syllable-final realizations of /l/ should be viewed as two separate allophones or just as different realizations of a single allophone.

Our view regarding this issue is that the phonetic implementation of the positional realizations of /l/ ought to be related to the articulatory constraints involved in the production of different varieties of the alveolar lateral as well as to universal position-dependent patterns of articulatory strengthening and reduction. Data in the literature suggest that in this respect dialects may be divided into at least three groups: ***(a)***, ***(b)*** and ***(c)***.

(a) Several languages and dialects exhibit a strongly dark variety of /l/ in all positions, i.e. Scottish and American English, Russian, Polish, Albanian and Bulgarian (von Essen 1964, Schubiger 1970: 87, Wells 1982, 2: 390, Scatton 1984, Catford 1988: 109, Ladefoged & Maddieson 1996: 197). This distribution may be related to the fact that dark /l/ is set in contrast with a clear cognate in the same language whether apical (Albanian) or palatalized (Russian, Polish, Bulgarian).

These sound systems either show essentially the same realization of /l/ word-initially and word-finally, or else a slightly clearer realization in the former position than the latter. Russian, European Portuguese and Leeds British English belong to the former group since word-initial /l/ has a very low F2 frequency about 1000 Hz or less in this case (table 1). American English belongs to the latter group (Kenyon 1950: 155, Delattre 1965: 88, Wells 1982). Indeed, American English /l/ has a higher F1 and a slightly lower F2 word-finally than word-initially across vowel environments (455 Hz vs. 295 Hz for F1, 795 Hz vs. 950 Hz for F2; Lehiste 1964) as well as in the context of /i/ (table 1). In agreement with these acoustic data, postvocalic /l/ is produced with some more tongue dorsum retraction and predorsum lowering than prevocalic /l/ but a similar closure location (Delattre 1965: 88, Giles & Moll 1975, Recasens & Farnetani 1990).

(b) Larger acoustic differences as a function of syllable position occur in dialects where /l/ is as dark or less dark than in those listed under ***(a)***. Thus, several varieties of British English appear to have two distinctive positional allophones of /l/ (Catford 1988: 109). Data for /l/ in British English RP show very different position-dependent F1 and F2 ranges across vowel contexts, i.e. 350–550 Hz and 700–1000 Hz word-finally, and 300–425 Hz and 1100–1600 Hz word-initially (Bladon & Al-Bamerni 1976; see also table 1). F2 values are also much higher for word-initial /l/ than for word-final /l/ in Newcastle British English (table 1) and in Southern British English (i.e. 1262 Hz vs. 969 Hz across vowel contexts according to Barry 2000).

Dark /l/ in Eastern Catalan also shows a higher F1 and a lower F2, and is articulated with less dorsopalatal contact and more closure fronting, in syllable-final position than in syllable-initial position (Recasens 1986, Recasens & Farnetani 1990). Formant ranges across vowel contexts amount to 350–450 Hz (F1) and 800–1050 Hz (F2) for word-final /l/, and to 250–350 Hz (F1) and 900–1250 Hz (F2) for word-initial /l/, with the largest differences occurring next to /i/ (see table 1). Apparently, a darker variety of /l/ in Eastern Catalan at the beginning of the 20th century was associated with the absence of positional differences in degree of darkness (see section 1.1 above).

(c) Languages and dialects with a clear variety of /l/ have been reported to exhibit the same or a highly similar realization of the alveolar lateral syllable-initially and syllable-finally, i.e. German, Spanish, French and Italian (Delattre 1965: 89–90, Schubiger, 1970: 87, Recasens & Farnetani 1990), and Irish English, Southern American English and Northern British English (Kenyon 1950: 155; Wells 1982, 2: 371, 390; Catford 1988:109). Thus, F2 data for Spanish and French /l/ in table 1 reveal small position-dependent differences and even higher values word-finally than word-initially in the /i/ context (Quilis, Esgueva, Gutiérrez Araus & Cantarero 1979, Chafcouloff 1985). Mean F1 and F2 data across vowel contexts taken from the same literature sources conform to a similar trend, i.e. 327 Hz and 1587 Hz word-initially and 329 Hz and 1564 Hz word-finally in Spanish, and 254 Hz and 1523 Hz and 252 Hz and 1454 Hz in French.

It may be assumed that syllable-position-dependent differences in degree of darkness for /l/ reflect the well-known trend for consonants to strengthen syllable-initially and not to strengthen or to undergo articulatory reduction syllable-finally (Fougeron 1999, Recasens 2004b). Differences in dorsopalatal contact (and in closure or constriction fronting) appear to be correlated with such differences in syllable affiliation, i.e. strengthening causes an increase in tongue dorsum raising syllable-initially and articulatory reduction causes some tongue dorsum lowering syllable-finally. Within this framework, the failure of dark /l/ to exhibit two positional allophones if it is strongly dark can be accounted for assuming that consonants undergo strengthening syllable-initially and reduction syllable-finally only if they are relatively unconstrained. If so, the strict articulatory requirements involved in the execution of active predorsum lowering and postdorsum retraction for strongly dark /l/ would account for why this consonantal variety does not become clearer syllable-initially. This hypothesis is supported by data showing that other consonants specified for demanding manner and place of articulation requirements, i.e. trills, fricatives and dorsal consonants, are also reluctant to exhibit articulatory differences as a function of syllable position (Browman & Goldstein 1995, Keating, Wright & Zhang 1999, Recasens 2004b).

The validity of this hypothesis is called into question, however, by the existence of dialects such as Brazilian Portuguese with a strongly dark realization of /l/ in syllable-final position (which may even become vocalized utterance-finally) and a much clearer realization of the consonant in syllable-initial position (Feldman 1972). Another problem is that clear /l/ in Italian, Spanish and French does not exhibit syllable-position differences in degree of darkness in spite of this variety of the alveolar lateral being less constrained than dark /l/. These objections suggest that other aspects besides degree of articulatory constraint ought to play a role in the allophonic distribution of /l/.

In agreement with the scenario for other languages and dialects, EPG and acoustic data for Majorcan and Valencian reported in this paper will allow testing of whether sound systems with a strongly dark or a clear variety of /l/ exhibit the same phonetic realization initially and finally. As already mentioned earlier, clear /l/ in Valencian is especially interesting since it appears to be produced with a similar tongue configuration to that for dark /l/ in the adjacency of the vowel /a/.

1.4 Coarticulatory resistance

The extent to which consonants are influenced by contextual vowels may be influenced by two factors, i.e. the articulatory requirements for the consonant (see sections 1.4.1 and 1.4.2 below) and the position that the consonant occupies within the word or the syllable (see section 1.4.3). This study also investigates the relative contribution of these two factors to the degree of vowel coarticulation allowed by dark /l/ in Majorcan Catalan and by clear /l/ in Valencian in initial, intervocalic and final position.

1.4.1 Tongue dorsum coarticulation

Previous studies show that vowel-dependent coarticulatory resistance for /l/ is dependent on degree of velarization or pharyngealization. In comparison with clear /l/ in German or Italian, dark /l/ in Eastern Catalan or American English allows less V-to-C coarticulation at the palatal zone in VCV sequences (Recasens & Farnetani 1990, Recasens, Fontdevila & Pallarès 1996). Thus, active tongue dorsum lowering causes dark /l/ to exhibit a similar tongue configuration irrespective of whether it is placed next to front or back vowels, or else small dorsopalatal contact differences in vowel height for /i, u/ > /a/ (American English) or in vowel fronting for /i/ > /a, u/ (Eastern Catalan). Vowel effects in tongue dorsum contact for clear /l/ resemble those for other alveolars such as /n/, and occur in vowel fronting and height for /i/ > /u/ > /a/ (Italian, German).

In agreement with these patterns of coarticulatory resistance, a quantitative index of degree of coarticulation in intervocalic position (i.e. MCD[3] or mean coarticulatory distance between /ili/ and /ala/) shows values below 250 Hz for dark /l/ and between 75 Hz and 500 Hz for clear /l/ (see table 1). MCD values for the Catalan dialects under investigation in the present study occur within those ranges, i.e. 408 Hz in Valencian and 73 Hz in Majorcan. Judging from the F2 values for /l/ across vowel contexts and dialects in the table, a very high MCD value for Valencian appears to be associated with a low F2 frequency for the consonant in the sequence /ala/.

1.4.2 Coarticulation at the place of articulation

Differences in vocalic coarticulation between dark /l/ and clear /l/ also occur at the place of articulation. Thus, dark /l/ exhibits a highly invariant dentoalveolar constriction across /i, a, u/ in American English (Recasens & Farnetani 1990), while clear /l/ shows a more variable constriction location over the entire alveolar zone as a function of the adjacent vowels in Spanish (Fernández Planas 2000). Moreover, there is also some evidence that high front /i/ or high /i, u/ cause a more extended closure to occur for clear /l/ in German than for dark /l/ in Catalan (Recasens et al. 1996). These findings are in accordance with differences in articulatory constraint between the two varieties of /l/ resulting in changes in alveolar closure location which parallel differences in tongue body fronting or in an increase in postalveolar central contact as the tongue dorsum is raised.

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[3] Mean coarticulatory distance (MCD) provides an estimate of the degree of coarticulation and has been calculated using the formula proposed by Bladon & Al-Bamerni (1976):

$$\mathrm{MCD} = \frac{\mathrm{F}_{l(i)} - \mathrm{F2}_{l(a)}}{2}$$

In the formula, ‘l(i)’ and ‘l(a)’ represent the consonant /l/ in the context of /i/ and in the context of /a/, respectively.

1.4.3 Position

Another issue is whether vocalic coarticulation for /l/ varies as a function of position. Different strategies are possible in this respect (see Fougeron & Keating 1997). It may be that the degree of vowel coarticulation changes inversely with differences in articulatory constraint for the positional allophones of /l/. If so, initial /l/ will allow more coarticulation than final /l/ if the former is clearer than the latter, or else initial /l/ and final /l/ will allow similar degrees of V-to-C coarticulation if they both exhibit analogous degrees of darkness.

Another option is that differences in coarticulation conform to position-dependent differences in articulatory salience. In this case, more articulatory strengthening for initial /l/ than for final /l/ is expected to render the former allophone more coarticulation resistant than the latter. The opposite outcome, i.e. initial /l/ may turn out to be less resistant than final /l/, may also hold if speakers attempt to enhance specific contextual properties in salient positions such as palatality for /li/ and labiality and velarity for /lu/. According to research in progress, this possibility is in accordance with a trend for the degree of coarticulation for palatal consonants to vary positively rather than inversely with differences in dorsopalatal contact size as a function of word position, i.e. dorsopalatal contact size and degree of vowel coarticulation at the palatal zone are higher word-initially than word-finally. It should be kept in mind, however, that the scenario for palatals differs from that for /l/ in that contextual enhancement for the former consonant class may be assisted by a blending mechanism between adjacent consonants and vowels sharing the same or contiguous primary articulator(s).

MCD values for clear /l/ and dark /l/ in initial and final position in table 1 are in agreement with the notion that coarticulatory sensitivity is ruled by position-dependent differences in degree of darkness. Thus, accordingly to dorsopalatal contact data in the literature (Recasens & Farnetani 1990), dark /l/ shows a higher MCD value word-initially than word-finally in dialects exhibiting two positional allophones such as Eastern Catalan, British English RP and American English. (No MCD data are available for dialects exhibiting a strongly dark /l/ type in both word positions.) Moreover, MCD values for clear /l/ in Spanish and French are not higher word-initially than word-finally, presumably because the alveolar lateral is equally clear in the two positions in this case.

2 Method

Electropalatographic (EPG) and acoustic data were collected for /l/ next to /i/, /a/ and /u/ in word-initial, intervocalic and word-final position. Seven repetitions of meaningful Catalan words containing the consonants and vowels of interest were uttered by five male speakers of Majorcan Catalan (AR, BM, MJ, ND, CA) and by five male speakers of Valencian (VB, JM, MS, VG, AV) in short meaningful expressions, e.g. *litres de llet* 'liters of milk', *ingerí líquid* 'he/she swallowed liquid' and *no li fa mal* 'it does not hurt him/her' where /l/ occupies the word-initial, intervocalic and word-final position, respectively. Word-initial and word-final consonants were also utterance-initial and utterance-final and therefore, were neither preceded nor followed by any other word in the sentence. The list of expressions used in the experiment is presented in table 2.

Linguopalatal contact configurations were gathered with the Reading EPG-3 system every 10 ms using artificial palates equipped with 62 electrodes. Acoustic data were digitized at 10 kHz, filtered at 4.8 kHz, and processed with a Kay CSL analysis system using the same temporal resolution as the EPG data.

Onset and offset of /l/ were determined on the EPG signal by the presence of full activation on electrodes placed at the two central columns of the artificial palate. Whenever central closure was not available (for speaker AR and occasionally for speaker CA), the onset and offset of /l/ were determined from inspection of spectrographic displays and identified with the edges of the vowel formant transitions. Linguopalatal contact data for /l/ were analyzed

Table 2 Majorcan Catalan sentences used for experimental analysis.

1. /li/	*litres de llet*	'liters of milk'
2. /la/	*laca molt bona*	'very good varnish'
3. /lu/	*lupa francesa*	'French lens'
4. /ili/	*ingerí liquid*	'he/she swallowed liquid'
5. /ala/	*visità l'atic*	'he/she visited the top floor'
6. /ulu/	*parla zulú bé*	'he/she speaks Zulu fluently'
7. /il/	*en venen mil*	'they sell a thousand'
8. /al/	*no li fa mal*	'it does not hurt him/her'
9. /ul/	*va i cau de cul*	'while walking, he/she fell down'

at a single frame, i.e. at PMC (point of maximum linguopalatal constriction) or at the frame showing the highest number of on-electrodes. Whenever a linguopalatal contact maximum lasted for more than one frame, PMC was taken to occur at the medial frame (if the number of frames exhibiting a maximum contact degree was 3, 5, . . .) or at the first of two consecutive frames (if the number of frames exhibiting maximum contact was 2, 4, . . .).

As shown by the EPG contact configurations in figure 1a, electrodes are arranged in eight rows and in four columns on each half of the artificial palate. The frontmost row 1 (just behind the upper teeth) is displayed at the top of the graphs and the backmost row 8 (just in front of the soft palate) at the bottom. The palate surface has been subdivided into four articulatory zones for data interpretation, i.e. front alveolar (rows 1, 2), postalveolar (rows 3, 4), prepalatal (rows 5, 6), mediopalatal (7) and postpalatal (8). Electrodes appear in black, grey or white depending on frequency of activation across repetitions, i.e. 80–100% (black), 40–80% (grey) and less than 40% (white).

Contact changes at the place of articulation and at the palatal zone were computed using the contact indices CAa (contact anteriority at the alveolar zone), CPa (contact posteriority at the alveolar zone) and Qp (quotient of overall electrode activation at the palatal zone). The computation of two alveolar contact indices is justified by the fact that we wanted to estimate the degree of alveolar constriction fronting as well as the overall contact area at the place of articulation. The choice of CPa was also based on the observation that CAa values could not be used to predict articulatory fronting for Majorcan Catalan /l/. Thus, CAa for this consonant realization was more sensitive to changes in contact degree at back closure location than to constriction location itself, which occurred invariably at the dentoalveolar zone irrespective of context, position and speaker.

The index Qp was obtained averaging all contacted electrodes at the palatal zone by the total number of 32 electrodes. The indices CAa and CPa were applied to the four front rows using the following formula (Fontdevila, Pallarès & Recasens 1994):

$$\mathrm{CAa} = [\log[[1(R_4/8) + 9(R_3/8) + 81(R_2/8) + 547(R_1/6)] + 1]]/[\log(638 + 1)]$$

$$\mathrm{CPa} = [\log[[1(R_1/6) + 9(R_2/8) + 81(R_3/8) + 729(R_4/8)] + 1]]/[\log(820 + 1)]$$

In the ratios within parentheses, the number of contacted electrodes on a given row (i.e. R4, R3, etc.) is divided by the total number of electrodes on that row. Each ratio is multiplied by a coefficient number. These coefficients are chosen so that the activation of all electrodes at and behind a specific row always yields a lower (CAa) or higher (CPa) index value than the activation of a single electrode at more anterior rows.

In addition to linguopalatal contact data, F1, F2 and F3 frequencies were measured manually on spectrographic displays, such those in figure 2, with the help of LPC spectral sections using the Kay CSL system. Similar articulatory and coarticulatory trends were expected to hold for Qp and F2 (and to a large extent for Qp and F1), and for CAa and F3.

This assumption follows from the specific articulatory–acoustic relationships for /l/ pointed out in the literature (Fant 1960, Bladon 1979, Stevens 1998): F2 is positively related to tongue dorsum raising and fronting and dorsopalatal contact size, and inversely related to the length of the back cavity behind the primary constriction and to back constriction narrowing; F1 is positively related to oral opening and tongue dorsum lowering, and to the cross-sectional of the lateral constriction; F3 is front-cavity dependent. Formant values for /l/ in the context of /u/ are also conditioned by lip rounding.

Tracking F3 (but not F1 and F2) was hard in some instances, referred to in section 3.1.1 below, presumably due to the presence of a spectral zero which appears to be associated with the shunting effect of the mouth cavity behind the tongue blade (Fant 1960). The zero may suppress F3 such that F4 takes over its role.

ANOVAs with repeated measures were performed on the CPa, Qp, F1 and F2 data as a function of the independent variables 'position' (word-initial, intervocalic, word-final), 'vowel context' (/i/, /a/, /u/) and 'dialect' (Majorcan, Valencian). This statistical test was not applied to CAa and F3, given that Majorcan Catalan dark /l/ was always produced with a full closure at row 1 and the third formant could not be measured on spectrographic displays in some cases (see above). The level of significance in all statistical analyses was $p < 0.05$, and Bonferroni multiple comparisons tests were applied to significant main effects and interactions. Since main effects and interactions involving the factor 'dialect' turned out to be almost always significant, ANOVAs and post hoc tests were also run on the articulatory and acoustic values for each dialect, including CAa for Valencian clear /l/. CAa and CPa values for speaker AR were excluded from both the ANOVAs for the entire data set and the ANOVAs for Majorcan Catalan in view of the fact that this speaker exhibited realizations of /l/ lacking an alveolar closure (see section 3.1.1).

3 Results

3.1 General articulatory and acoustic characteristics

3.1.1 Closure location, F3

Inspection of the EPG contact patterns in figures 1a and 1b reveals the presence of a complete closure independently of position and vowel context for all speakers of Valencian and for four speakers of Majorcan (BM, MJ, ND, CA). Speaker AR shows a complete closure for /il#, al#, ul#/, but no central alveolar contact or just some contact at the sides of the alveolar zone for /#li, #la, #lu/ and for /ili, ala, ulu/ (see figure 1a, top). Failure to achieve full closure may be due to a more domed palate shape for this speaker than for the other Majorcan speakers. Thus, measures of maximum palate height taken at about rows 7 and 8 of the artificial palate reveal the existence of a larger vertical distance for speaker AR (26 mm) than for speakers CA (19 mm) and BM, MJ and ND (17 mm). It happens to be the case, however, that central closure was occasionally absent for speaker CA as well, i.e. there was only one on-electrode on row 1 in one repetition of /ili, ala/ and no central closure in two repetitions of /ulu/.

Closure location was highly fixed for dark /l/ in Majorcan and more variable for clear /l/ in Valencian. As shown by the mean VCV contact configurations in figure 1a, the alveolar closure for the former variety of /l/ always included row 1, meaning that the consonant is dental or more properly dentoalveolar in Majorcan. Closure for Valencian clear /l/ may occur at rows 1, 2 and/or 3 (see figure 1b) except for word-final /l/ for speaker JM, which could be articulated anywhere between rows 1 and 4. Consistently with these contact configurations, CAa values in tables 3a and 3b approach 1 for dark /l/ in Majorcan (i.e. mean CA values across speakers exceed 0.97 in this case) and vary a great deal for clear /l/ in Valencian. Judging from the fact that central closure occurs at one row of electrodes for most Majorcan

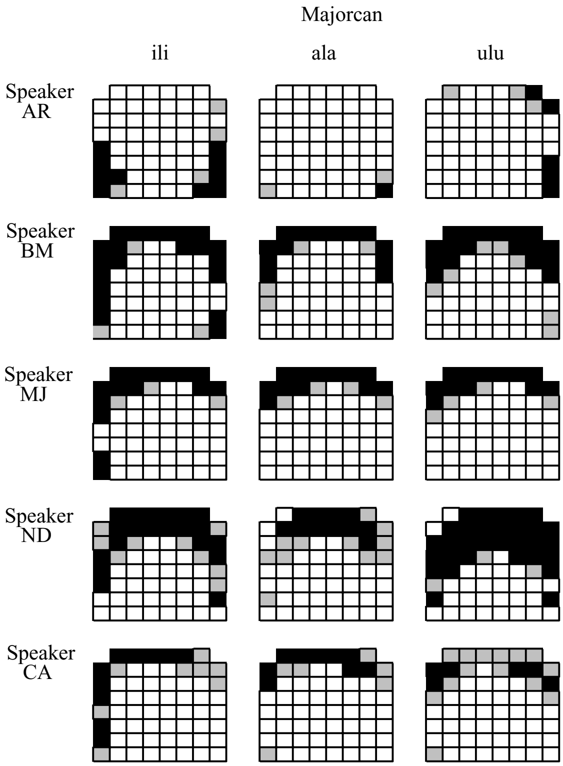


Figure 1a Mean linguopalatal contact configurations for dark /l/ in the intervocalic sequences /ili/, /ala/ and /ulu/ according to five speakers of Majorcan Catalan. Data correspond to PMC or point of maximal constriction.

speakers, it may be hypothesized that dark /l/ is apical rather than laminal in this dialect. A similar observation applies, though less clearly, to clear /l/ in Valencian.

F3 frequencies in tables 3a and 3b are much higher for dark /l/ than for clear /l/, in accordance with the former consonantal variety exhibiting higher CAa values and thus being produced with a shorter front cavity than the latter. Thus, F3 for dark /l/ in Majorcan Catalan ranges between about 2500 Hz and 3300 Hz except for a few extreme cases, i.e. 3515 Hz for /lu/ for speaker ND and 2309 Hz for /ala/ for speaker MJ. On the other hand, F3 for clear /l/ in Valencian Catalan occurs between about 2075 Hz and 2755 Hz next to /i, a/ and may lower down to about 1400 Hz, 1600 Hz or 1800 Hz in the neighbourhood of /u/. Therefore, clear /l/ appears to be more sensitive to lip rounding effects than its dark cognate.

In contrast with dialect-dependent contact differences at the front alveolar zone, ANOVAs yielded non-significant dialect-dependent differences in CPa and thus in contact size at the back closure area (see CPa values for dark /l/ and clear /l/ as a function of position, vowel and speaker in tables 3a and 3b).

In some sequences (mostly /#lu/), clear /l/ in Valencian underwent continuous fronting from the postalveolar to the front alveolar zone during the closure period. No instances of gradual closure fronting occurred for dark /l/ in Majorcan. The presence or absence of such variations in closure placement may be attributed to differences in tongue body constraint between the two varieties of /l/, i.e. to the fact that the tongue body is subject to less strict demands for clear /l/ than for dark /l/.

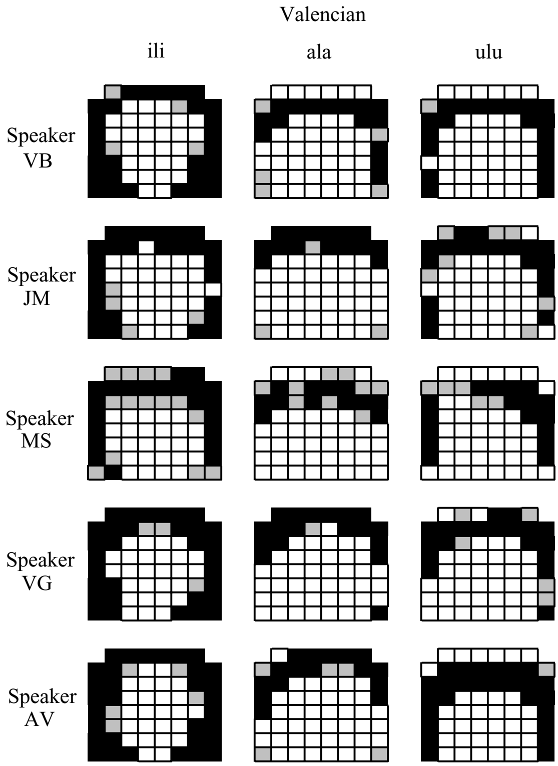


Figure 1b Mean linguopalatal contact configurations for clear /l/ in the intervocalic sequences /ili/, /ala/ and /ulu/ according to five speakers of Valencian Catalan. Data correspond to PMC or point of maximal constriction.

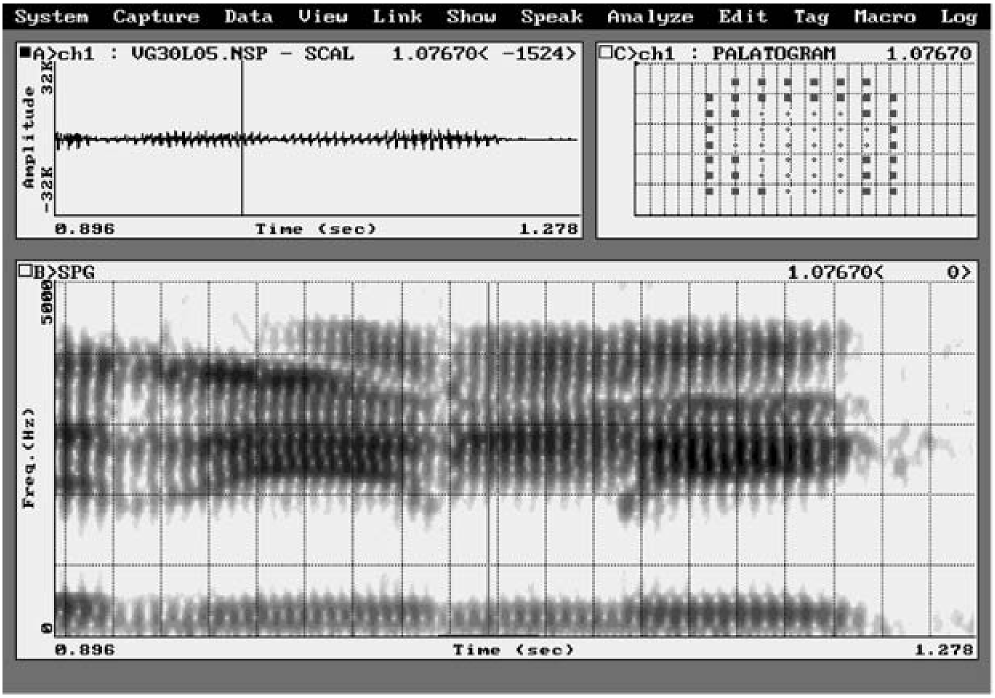
3.1.2 Tongue dorsum contact, F2

Dialect-dependent differences in Qp and F2 turned out to be highly significant, which is in agreement with differences in degree of darkness between Majorcan dark /l/ and Valencian clear /l/ ($F(1, 68) = 62.43$, $p < 0.000$; $F(1, 68) = 147.86$, $p < 0.001$).

As shown in tables 3a and 3b, /l/ was found to exhibit much less dorsopalatal contact and a much lower F2 in Majorcan than in Valencian. Thus, cross-speaker Qp and F2 ranges for the two varieties of /l/ in the sequence /ili/ show practically no overlap, i.e. 0.07–0.36 (Majorcan) and 0.30–0.54 (Valencian), and 1023–1397 Hz (Majorcan) and 1566–2223 Hz (Valencian). Spectrograms for /ili/ in figure 2 reveal the presence of a typical F2 above 2000 Hz for Valencian clear /l/ (top graph) and a typical F2 just above 1000 Hz for Majorcan dark /l/ (bottom graph). Ranges for the sequence /ala/, on the other hand, are slightly higher in Valencian (Qp = 0–0.13, F2 = 983–1354 Hz) than in Majorcan (Qp = 0–0.07; F2 = 1017–1177 Hz) though clearly lower and smaller for clear /l/ in Valencian than for clear /l/ in other languages and dialects in the literature. Inspection of the dorsopalatal contact area at the four back rows of the artificial palate in figures 1a and 1b reveals dialect-dependent differences for /ili/ but not for /ala/.

3.1.3 Closure duration, F1, voicing

Dialect-dependent differences in closure duration turned out to be highly significant which is also in accordance with dialect-dependent differences in degree of darkness ($F(1, 61) = 14.99$, $p < 0.001$). Mean durations across speakers in figure 3 reveal that closure duration happens to be shorter in Valencian than in Majorcan in all word positions.



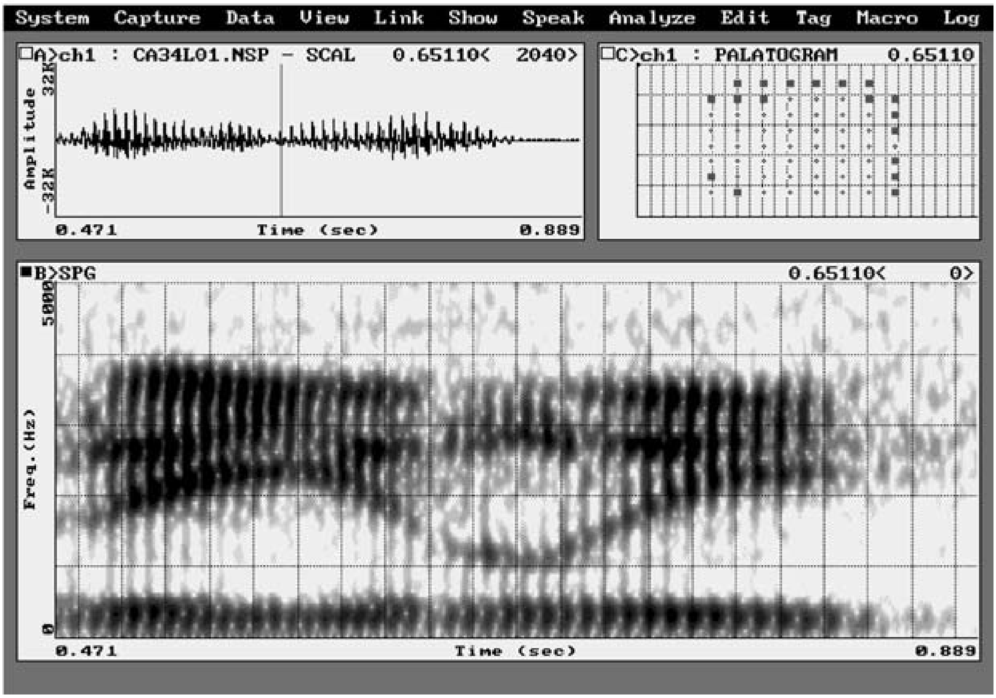


Figure 2 Representation of the acoustic waveform, linguopalatal contact configuration and spectrogram for Valencian clear /l/ (top graph) and Majorcan dark /l/ (bottom graph) in the sequence /ili/ (sentence *Ingerí líquid* 'I ingested liquid'). Data correspond to speakers VG (Valencian) and CA (Majorcan). The EPG configurations correspond to the lateral at the temporal frame where the cursor appears on the waveform.

Table 3a Mean CAa, CPa and Qp index values, and F1, F2 and F3 frequency values, for dark /l/ in Majorcan Catalan as a function of position, vowel context and speaker. Standard deviations are also given in italics except when the number of tokens is less than four. CAa and CPa values for speaker AR have been excluded since /l/ was vocalized in this case.

	Initial			Intervocalic			Final			Initial			Intervocalic			Final		
	i	a	u	i	a	u	i	a	u	i	a	u	i	a	u	i	a	u
					CAa									**F1**				
AR										414	443	351	374	617	340	363	443	349
										27.6	*18.0*	*22.7*	*19.0*	*26.9*	*20.0*	*29.3*	*24.3*	*22.7*
BM	1.000	0.998	1.000	0.988	0.985	0.997	0.998	0.998	0.998	417	489	396	400	620	386	466	551	417
	0.000	*0.003*	*0.000*	*0.012*	*0.012*	*0.003*	*0.002*	*0.002*	*0.002*	*62.6*	*34.4*	*7.9*	*25.8*	*28.3*	*41.2*	*25.1*	*88.6*	*43.9*
MJ	0.998	0.994	0.998	0.988	0.994	0.992	0.996	0.996	0.992	423	460	373	383	566	337	411	463	391
	0.001	*0.002*	*0.002*	*0.012*	*0.004*	*0.003*	*0.002*	*0.001*	*0.003*	*39.0*	*25.8*	*15.0*	*33.5*	*22.3*	*37.3*	*52.7*	*24.3*	*30.2*
ND	0.997	1.000	0.997	0.996	0.968	0.936	1.000	1.000	0.987	314	403	343	320	471	329	374	380	354
	0.009	*0.000*	*0.009*	*0.003*	*0.023*	*0.112*	*0.001*	*0.001*	*0.034*	*15.1*	*21.4*	*21.4*	*23.1*	*27.9*	*25.4*	*19.0*	*23.1*	*19.0*
CA	0.994	0.999	0.999	0.975	0.987	0.985	0.993	0.995	0.994	331	449	337	349	549	349	363	454	340
	0.014	*0.000*	*0.001*	*0.019*	*0.013*	*0.013*	*0.013*	*0.009*	*0.010*	*50.1*	*25.4*	*21.4*	*19.5*	*39.8*	*25.4*	*35.5*	*27.6*	*16.3*
					CPa									**F2**				
AR										1151	1060	949	1397	1177	814	1094	1026	889
										55.2	*99.3*	*30.2*	*92.0*	*33.5*	*55.0*	*25.1*	*48.6*	*38.0*
BM	0.906	0.856	0.923	0.825	0.798	0.847	0.835	0.851	0.842	1020	977	836	1351	1143	823	1137	966	783
	0.031	*0.044*	*0.013*	*0.040*	*0.004*	*0.043*	*0.037*	*0.051*	*0.028*	*145.1*	*69.7*	*50.9*	*44.5*	*24.3*	*21.4*	*46.8*	*103.1*	*62.6*
MJ	0.709	0.780	0.739	0.737	0.558	0.636	0.741	0.751	0.590	806	817	810	1023	1017	749	857	886	786
	0.110	*0.042*	*0.031*	*0.047*	*0.127*	*0.141*	*0.043*	*0.111*	*0.151*	*81.4*	*80.4*	*30.0*	*105.5*	*37.3*	*50.1*	*77.8*	*37.8*	*29.9*
ND	0.974	0.965	0.982	0.831	0.750	0.973	0.966	0.979	0.990	1011	820	746	1220	1026	763	900	929	871
	0.033	*0.032*	*0.015*	*0.153*	*0.213*	*0.010*	*0.028*	*0.017*	*0.015*	*72.0*	*103.3*	*62.9*	*137.1*	*44.3*	*33.5*	*20.0*	*30.2*	*58.7*
CA	0.780	0.849	0.807	0.704	0.498	0.688	0.723	0.730	0.722	957	969	906	1151	1057	737	1094	1060	931
	0.063	*0.055*	*0.065*	*0.011*	*0.103*	*0.144*	*0.018*	*0.016*	*0.012*	*65.8*	*63.1*	*69.0*	*36.3*	*37.3*	*13.8*	*29.9*	*32.7*	*15.7*
					Qp									**F3**				
AR	0.071	0.063	0.031	0.362	0.067	0.112	0.063	0.076	0.022	2723	2780	2769	2683	2869	2870	2789	2811	2777
	0.072	*0.051*	*0.048*	*0.040*	*0.022*	*0.035*	*0.044*	*0.035*	*0.024*	*57.1*	*43.2*	*38.0*	*31.5*	*133.1*	*90.1*	*76.5*	*102.5*	*48.2*
BM	0.152	0.129	0.106	0.214	0.036	0.058	0.161	0.103	0.040	2530	2947	3120	2637	2811	2937	2720	2897	2907
	0.033	*0.064*	*0.039*	*0.052*	*0.033*	*0.049*	*0.042*	*0.035*	*0.030*	*155.6*	*125.0*		*129.9*	*55.2*	*190.9*	*220.0*	*241.5*	*264.9*
MJ	0.004	0.009	0.000	0.071	0.000	0.004	0.063	0.004	0.000	2790	2471	3067	2943	2309	3040	3033	2597	2900
	0.012	*0.015*	*0.000*	*0.015*	*0.000*	*0.012*	*0.018*	*0.012*	*0.000*	*217.9*	*174.3*	*98.7*	*55.9*	*134.1*	*52.9*	*30.1*	*125.1*	*69.3*
ND	0.161	0.107	0.147	0.156	0.036	0.192	0.134	0.103	0.116	3068	3171	3515	2684	3152	3147	3020	3280	2940
	0.061	*0.025*	*0.043*	*0.057*	*0.046*	*0.066*	*0.056*	*0.030*	*0.039*	*176.4*	*124.3*	*77.2*	*68.4*	*94.4*	*166.7*		*146.3*	
CA	0.129	0.156	0.121	0.103	0.018	0.031	0.089	0.089	0.018	2885	2966	2972	2717	2983	3020	3050	3089	2923
	0.049	*0.044*	*0.066*	*0.035*	*0.025*	*0.044*	*0.101*	*0.042*	*0.017*	*66.1*	*83.0*	*17.9*	*62.6*	*43.9*	*72.7*	*64.2*	*54.0*	*84.3*

Table 3b Mean CAa, CPa and Qp index values, and F1, F2 and F3 frequency values, for clear /l/ in Valencian Catalan as a function of position, vowel context and speaker. Standard deviations are also given in italics except when the number of tokens is less than four. No F3 data are available for the sequence /ulu/ in the case of speaker JM.

	Initial			Intervocalic			Final		
	i	a	u	i	a	u	i	a	u
					CAa				
VB	**0.964**	**0.956**	**0.901**	**0.978**	**0.708**	**0.681**	**0.963**	**0.968**	**0.789**
	0.014	*0.042*	*0.109*	*0.012*	*0.071*	*0.010*	*0.023*	*0.004*	*0.162*
JM	**0.918**	**0.925**	**0.232**	**0.996**	**0.996**	**0.938**	**0.977**	**0.796**	**0.925**
	0.159	*0.155*	*0.069*	*0.003*	*0.003*	*0.038*	*0.048*	*0.179*	*0.110*
MS	**0.812**	**0.889**	**0.849**	**0.941**	**0.789**	**0.684**	**0.979**	**0.776**	**0.581**
	0.282	*0.255*	*0.189*	*0.079*	*0.139*	*0.122*	*0.052*	*0.241*	*0.122*
VG	**0.896**	**0.996**	**0.953**	**0.997**	**0.995**	**0.928**	**0.996**	**0.994**	**0.969**
	0.234	*0.003*	*0.120*	*0.002*	*0.003*	*0.056*	*0.009*	*0.009*	*0.048*
AV	**0.534**	**0.824**	**0.543**	**0.993**	**0.974**	**0.685**	**0.991**	**0.829**	**0.903**
	0.245	*0.164*	*0.295*	*0.004*	*0.011*	*0.060*	*0.003*	*0.207*	*0.140*
					CPa				
VB	**0.749**	**0.726**	**0.739**	**0.809**	**0.781**	**0.814**	**0.741**	**0.687**	**0.786**
	0.041	*0.011*	*0.032*	*0.021*	*0.044*	*0.003*	*0.042*	*0.087*	*0.041*
JM	**0.719**	**0.700**	**0.928**	**0.800**	**0.560**	**0.767**	**0.571**	**0.771**	**0.782**
	0.229	*0.215*	*0.040*	*0.005*	*0.115*	*0.047*	*0.145*	*0.249*	*0.053*
MS	**0.876**	**0.850**	**0.901**	**0.849**	**0.856**	**0.859**	**0.833**	**0.866**	**0.926**
	0.073	*0.074*	*0.066*	*0.038*	*0.069*	*0.025*	*0.031*	*0.091*	*0.048*
VG	**0.870**	**0.806**	**0.837**	**0.812**	**0.796**	**0.837**	**0.835**	**0.825**	**0.861**
	0.068	*0.007*	*0.038*	*0.001*	*0.032*	*0.029*	*0.038*	*0.036*	*0.033*
AV	**0.956**	**0.888**	**0.915**	**0.874**	**0.814**	**0.912**	**0.802**	**0.879**	**0.833**
	0.052	*0.059*	*0.080*	*0.036*	*0.021*	*0.001*	*0.006*	*0.073*	*0.029*
					Qp				
VB	**0.232**	**0.112**	**0.170**	**0.542**	**0.134**	**0.223**	**0.205**	**0.027**	**0.116**
	0.035	*0.044*	*0.080*	*0.062*	*0.062*	*0.022*	*0.051*	*0.028*	*0.074*
JM	**0.130**	**0.022**	**0.313**	**0.384**	**0.040**	**0.201**	**0.071**	**0.045**	**0.013**
	0.104	*0.030*	*0.117*	*0.064*	*0.030*	*0.062*	*0.053*	*0.047*	*0.017*
MS	**0.143**	**0.054**	**0.152**	**0.299**	**0.004**	**0.205**	**0.071**	**0.031**	**0.054**
	0.025	*0.067*	*0.022*	*0.062*	*0.012*	*0.030*	*0.015*	*0.036*	*0.035*
VG	**0.237**	**0.201**	**0.085**	**0.460**	**0.031**	**0.125**	**0.330**	**0.049**	**0.080**
	0.051	*0.017*	*0.047*	*0.015*	*0.000*	*0.036*	*0.051*	*0.017*	*0.017*
AV	**0.313**	**0.241**	**0.228**	**0.504**	**0.080**	**0.250**	**0.250**	**0.143**	**0.143**
	0.088	*0.047*	*0.086*	*0.055*	*0.070*	*0.000*	*0.036*	*0.057*	*0.047*

	Initial			Intervocalic			Final		
	i	a	u	i	a	u	i	a	u
					F1				
VB	**449**	**511**	**369**	**340**	**514**	**340**	**440**	**489**	**437**
	25.4	*19.5*	*30.2*	*16.3*	*32.1*	*23.1*	*11.5*	*19.5*	*24.3*
JM	**333**	**423**	**357**	**394**	**490**	**357**	**371**	**463**	**397**
	15.0	*53.5*	*18.0*	*32.1*	*42.8*	*24.3*	*39.8*	*48.2*	*21.4*
MS	**349**	**477**	**334**	**323**	**526**	**349**	**403**	**483**	**334**
	34.4	*26.9*	*25.1*	*29.3*	*29.9*	*25.4*	*24.3*	*45.4*	*32.1*
VG	**334**	**449**	**343**	**277**	**537**	**343**	**274**	**443**	**346**
	25.1	*22.7*	*26.9*	*33.5*	*42.3*	*24.3*	*15.1*	*24.3*	*27.6*
AV	**360**	**451**	**334**	**311**	**517**	**331**	**423**	**509**	**411**
	34.6	*38.0*	*59.7*	*22.7*	*35.5*	*25.4*	*26.9*	*41.4*	*27.9*
					F2				
VB	**1420**	**1040**	**1197**	**2163**	**1120**	**991**	**1314**	**1089**	**1074**
	54.2	*66.3*	*114.0*	*74.3*	*20.0*	*19.5*	*42.8*	*57.6*	*78.1*
JM	**1553**	**1543**	**1537**	**1566**	**1317**	**1151**	**1520**	**1334**	**1394**
	106.3	*58.2*	*111.6*	*36.0*	*21.4*	*22.7*	*32.7*	*27.6*	*50.0*
MS	**1131**	**837**	**1057**	**1969**	**983**	**934**	**1011**	**869**	**880**
	143.7	*50.9*	*71.6*	*88.6*	*64.7*	*47.2*	*62.0*	*58.7*	*65.3*
VG	**1320**	**1269**	**1143**	**2223**	**1354**	**966**	**1311**	**1269**	**1014**
	98.7	*52.7*	*31.5*	*143.5*	*75.5*	*27.6*	*32.4*	*36.3*	*25.1*
AV	**1414**	**1060**	**1131**	**1989**	**1051**	**1034**	**1166**	**1046**	**1006**
	100.5	*38.3*	*63.1*	*71.0*	*57.6*	*70.0*	*44.3*	*36.0*	*25.1*
					F3				
VB	**2183**	**2320**	**2543**	**2587**	**2520**	**2586**	**2180**	**2754**	**2740**
	77.8	*176.6*	*93.4*	*62.8*	*52.9*	*74.6*	*74.8*	*55.0*	
JM	**2400**	**2449**	**1930**	**2400**	**2377**		**2580**	**2374**	**2411**
		179.6	*177.8*	*132.7*	*50.9*		*68.3*	*115.9*	*59.8*
MS	**2471**	**2315**	**1740**	**2326**	**2349**	**1444**	**2351**	**2391**	**1749**
	84.7	*91.5*	*148.3*	*70.0*	*51.5*	*60.7*	*19.5*	*128.0*	*79.9*
VG	**2231**	**2740**	**2714**	**2711**	**2671**	**1403**	**2077**	**2734**	**1586**
	119.4	*36.5*	*86.2*	*79.9*	*72.9*	*81.4*	*93.3*	*62.9*	*80.6*
AV	**2394**	**2257**	**2400**	**2363**	**2269**	**2407**	**2391**	**2117**	**1640**
	67.0	*124.2*		*39.0*	*134.1*	*83.3*	*41.4*	*145.3*	*98.8*

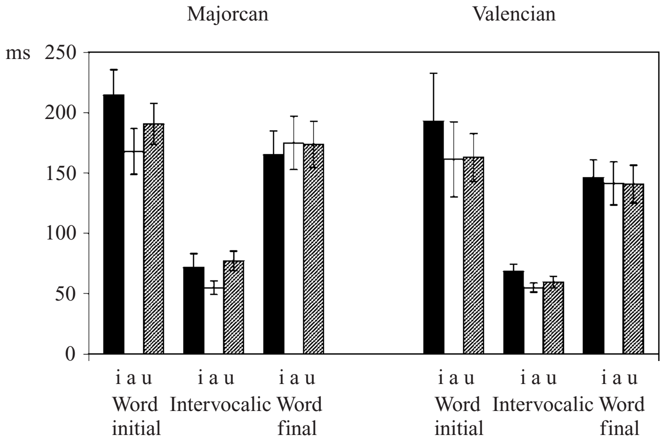


Figure 3 Mean closure duration for dark /l/ in Majorcan (left) and for clear /l/ in Valencian (right) as a function of position and vowel context. Data have been averaged across repetitions and speakers. Standard deviations are also given.

However, there were no dialect-dependent differences in F1 frequency, which suggests that the two varieties of /l/ are produced with similar degrees of oral opening (see F1 frequency values for all speakers in tables 3a and 3b).

In both dialects, voicing for word-initial /l/ starts during the second half of the closure period i.e. at 60–66% of the overall closure duration in Valencian and at 57–70% in Majorcan. Percentages of closure voicing did not differ significantly as a function of dialect. Relevant dialect-dependent differences occurred word-finally since voicing offset was found to take place at closure release or 26–38 ms after it in Valencian, and 36–66 ms before closure release in Majorcan.

3.2 Positional and vocalic effects

ANOVAs on closure durations yielded a significant effect of position ($F(1, 61) = 335.17$, $p < 0.001$) and vowel context ($F(1, 61) = 14.13$, $p < 0.001$), a significant position x vowel context interaction ($F(1, 61) = 8.00$, $p < 0.01$), but no significant interactions involving the factor ‘dialect’. As shown in figure 3, closure durations were found to decrease in the order word-initial, word-final > intervocalic in the context of /a, u/ (white and hatched bars) and word-initial > word-final > intervocalic in the context of /i/ (black bars). Moreover, they differed according to the contextual vowel word-initially (/i/ > /a, u/) and intervocalically (/i, u/ > /a/) but not in word-final position.

The factor ‘dialect’ interacted significantly with position and vowel context for the contact index and formant frequency measures subject to statistical treatment. Thus, a significant position x vowel context x dialect interaction was obtained for CPa ($F(1, 61) = 4.43$, $p < 0.05$), Qp ($F(1, 68) = 8.96$, $p < 0.01$), F1 ($F(4, 272) = 4.88$, $p < 0.001$) and F2 ($F(1, 68) = 58.78$, $p < 0.001$). Mean values and results for multiple comparisons tests for each dialect (see the ‘Method’ section above) are given in table 4 and in figures 4a and 4b. In the table, significant differences are marked with one, two or three asterisks depending on the level of significance, and the sign of those differences is also appended. Results are presented and discussed separately for Majorcan and Valencian in sections 3.2.1 and 3.2.2 below.

3.2.1 Majorcan

(a) CPa data for /l/ in Majorcan yielded significant position-dependent effects varying in the progression word-initial > word-final > intervocalic ($F(1, 27) = 39.84$, $p < 0.001$), no

Table 4 Results for multiple comparisons tests on significant position x vowel context interactions for dark /l/ in Majorcan Catalan (top) and clear /l/ in Valencian Catalan (bottom). Significant differences are marked with one, two or three asterisks depending on the level of significance (* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$). The sign of the significant effects is also given ($<$ = 'smaller than', $>$ = 'greater than'). Results are not reported for CAa for Majorcan /l/ (since this dialectal variety was consistently produced with a full closure at row 1) or for CAa and CPa for Valencian /l/ (since these index values yielded non significant position x vowel context interactions).

Majorcan

		CPa	Qp	F1	F2
Initial	i-a			*** <	
	i-u				*** >
	a-u			*** >	*** >
Intervocalic	i-a	*** >	*** >	*** <	*** >
	i-u		*** >		*** >
	a-u	*** <	*** <	*** >	*** >
Final	i-a			*** <	* >
	i-u		*** >	** >	*** >
	a-u		*** >	*** >	*** >
i	Initial-Intervocalic	** >	** <		*** <
	Initial-Final				
	Intervocalic-Final		** >	** <	*** >
a	Initial-Intervocalic	*** >	*** >	*** <	*** <
	Initial-Final				
	Intervocalic-Final	*** <	*** <	*** >	*** >
u	Initial-Intervocalic	** >			*** >
	Initial-Final	*** >	** >		
	Intervocalic-Final		** >	** <	*** <

Valencian

		Qp	F1	F2
Initial	i-a	*** >	*** <	*** >
	i-u			*** >
	a-u		*** >	
Intervocalic	i-a	*** >	*** <	*** >
	i-u	*** >		*** >
	a-u	*** <	*** >	*** >
Final	i-a	*** >	*** <	*** >
	i-u	*** >		*** >
	a-u		*** >	
i	Initial-Intervocalic	*** <	* >	*** <
	Initial-Final			*** >
	Intervocalic-Final	*** >	*** <	*** >
a	Initial-Intervocalic	*** >	*** <	
	Initial-Final	*** >		
	Intervocalic-Final		*** >	
u	Initial-Intervocalic			*** >
	Initial-Final	*** >	*** <	*** >
	Intervocalic-Final	*** >	*** <	* <

effects associated with vocalic context, and significant position x vowel context interactions ($F(1, 27) = 11.85$, $p < 0.01$). According to table 4, vowel-dependent differences appear to be significant in intervocalic position for /i, u/ > /a/ but not word-initially and word-finally. Consistently, bars for CPa in figure 4a (top left) are higher for /ili/ (black) and /ulu/ (hatched) vs. /ala/ (white), and show a similar height for all word-initial and word-final sequences. Statistical results in table 4 and bars in the figure also reveal the presence of higher and mostly significant CPa values word-initially and word-finally vs. intervocalically in the context of /i/ and /a/, and in word-initial position vs. intervocalic and word-final position in the context of /u/. CPa data in figure 4a show indeed higher bars for /#li, il#/ vs. /ili/ and for /#la, al#/ vs. /ala/, and a higher bar for /#lu/ than for /ulu, ul#/.

The finding of maximal alveolar contact posteriority for /l/ word-initially and word-finally next to non-labial vowels is indicative of maximal alveolar contact degree and suggests that a strengthening effect is taking place in both word positions. Moreover, a gain in tongue contact causes /l/ to be highly resistant to vowel effects in closure extent. More back closure retraction for /#lu/ vs. /ulu, ul#/ may occur in order to facilitate the implementation of anticipatory lip rounding effects associated with /u/ (see section 3.2.2***(a)*** below for a possible interpretation).

(b) Regarding Qp, there were significant main vowel context effects for /i/ > /a, u/ ($F(2, 68) = 44.66$, $p < 0.001$), no position-dependent effects, and significant vowel context x position interactions ($F(1, 34) = 19.20$, $p < 0.001$). Vowel-dependent differences in Qp were significant intervocalically for /i/ > /u/ > /a/ and word-finally for /i, a/ > /u/ but not word-initially (see table 4, and top right graph in figure 4a above). Moreover, significant position-dependent differences were found to vary in the progression intervocalic > word-initial, word-final (/i/), word-initial, word-final > intervocalic (/a/) and word-initial, intervocalic > word-final (/u/).

The absence of differences in tongue dorsum contact between the word-initial and word-final positions in the context of /i, a/ supports the notion that strongly dark varieties of /l/ do not oppose positional allophones specified for different degrees of velarization. Word-initial strengthening may account for a high degree of coarticulatory resistance in this word position. Moreover, the lateral appears to be more strongly velarized or pharyngealized after /u/ in word-final position, and therefore shows less dorsopalatal contact for /ul#/ than for other final sequences and for other sequences with /u/.

(c) ANOVAs on the F1 data yielded significant vowel context effects for /a/ > /i/ > /u/ ($F(2, 68) = 299.06$, $p < 0.001$), significant position effects varying in the progression intervocalic > word-initial, word-final ($F(1, 34) = 17.87$, $p < 0.001$) and significant position x vowel context interactions ($F(4,136) = 55.70$, $p < 0.001$). Significant vowel-dependent differences in F1 were found to hold word-initially and intervocalically for /a/ > /i, u/ and, even more so, word-finally for /a/ > /i/ > /u/ (see table 4, and bottom left graph in figure 4a). Moreover, significant position-dependent effects turned out to vary in a different progression for /i, u/ (word-finally > intervocalically, while the word-initial values do not differ significantly from those for the other two positions) and for /a/ (intervocalically > word-initially, word-finally).

F2 shows significant vowel context effects for /i/ > /a/ > /u/ ($F(1, 34) = 170.53$, $p < 0.001$), significantly higher values in intervocalic position than word-initial and word-final position ($F(1, 34) = 44.82$, $p < 0.001$), and significant position x vowel interactions ($F(1, 34) = 51.91$, $p < 0.001$). As revealed by table 4 and figure 4a (bottom right), statistical tests yield vowel-dependent differences as a function of position (i.e. /i, a/ > /u/ word-initially, and /i/ > /a/ > /u/ intervocalically and word-finally) and vowel context (i.e. intervocalic > word-initial, word-final when the contextual vowel is /i, a/, and word-initial, word-final > intervocalic in the adjacency of /u/).

These statistical data suggest that Majorcan dark /l/ is produced with more extreme degrees of oral opening (F1) and tongue height and fronting (F2) in intervocalic position than in word-initial and word-final position. Therefore, in comparison with word-initial and word-final /l/,

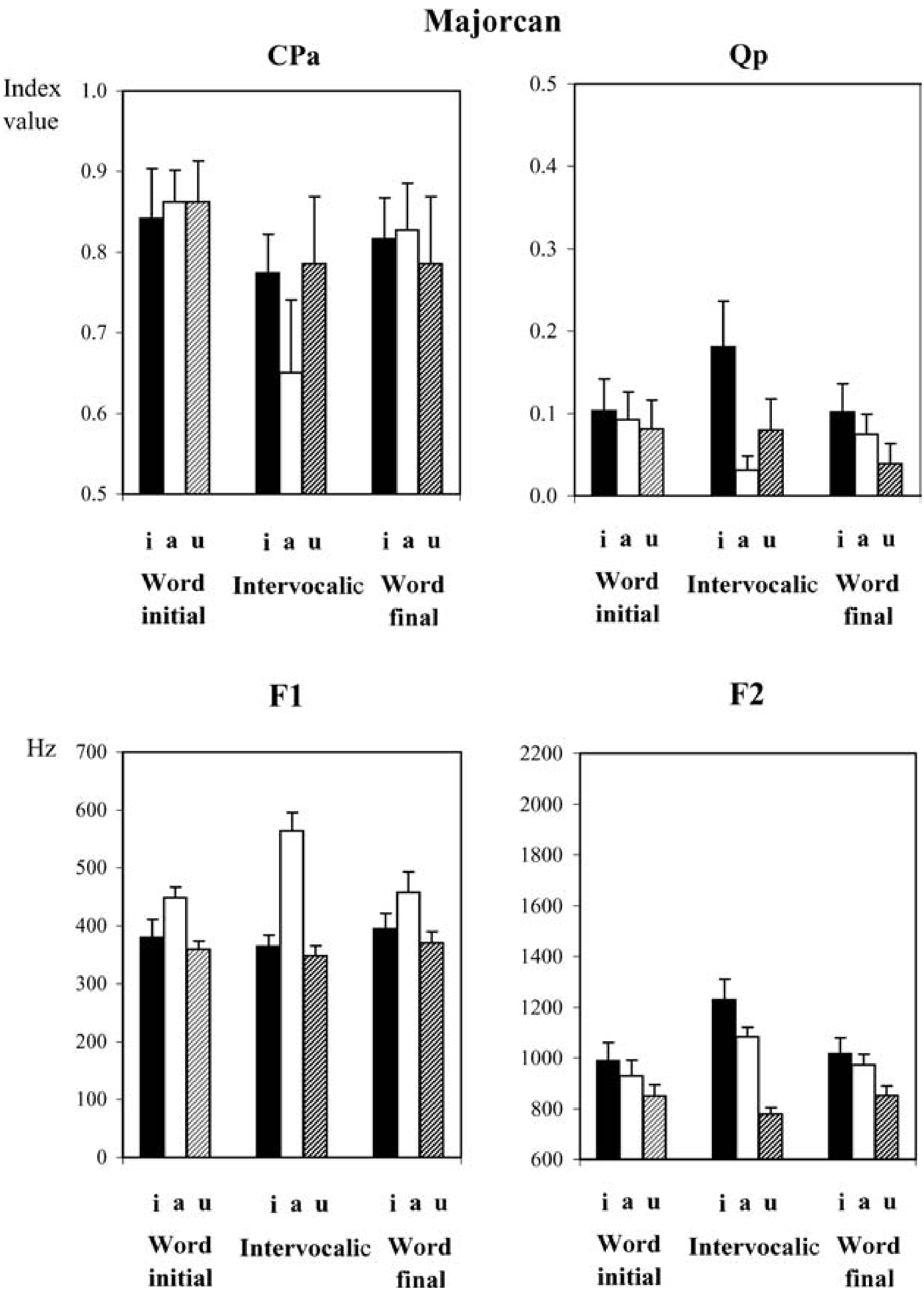


Figure 4a Mean CPa, Qp, F1 and F2 values for dark /l/ in Majorcan as a function of position and vowel context. Data have been averaged across repetitions and speakers. Standard deviations are also given.

intervocalic /l/ appears to involve less oral opening and more tongue fronting and raising next to /i/, and less oral opening and more tongue backing and lip rounding next to /u/. Regarding the /a/ context, F1 and F2 data suggest that /l/ is produced with more oral opening and tongue dorsum raising in the case of /ala/ than of /#la, al#/. More importantly and in accordance with the Qp data, word-initial and word-final /l/ exhibit similar formant frequencies, thus suggesting that the lateral is implemented through similar articulatory configurations in both word positions. Also in agreement with Qp, F2 turned out to be less sensitive to vowel coarticulation word-initially than word-finally and intervocalically, i.e. vocalic effects were associated with vowel rounding in the former position and involved all three vowels in the two latter positions.

3.2.2 Valencian

(a) ANOVAs on CAa for Valencian /l/ yielded significant main vocalic effects for /i, a/ > /u/ ($F(2, 68) = 35.29$, $p < 0.001$), and significant position-dependent differences conforming to the progression word-final > word-initial ($F(1, 34) = 5.41$, $p < 0.05$) while the intervocalic values did not differ significantly from those in the other two positions. On the other hand, CPa values turned out to be significantly higher for contextual /u/ vs. /i, a/ ($F(2, 68) = 13.73$, $p < 0.001$) and in word-initial vs. word-final position ($F(2, 68) = 4.00$, $p < 0.05$). Vowel context x position interactions for the CAa or CPa data did not reach significance, which is why table 4 above shows no corresponding results from multiple comparisons tests. Though non-significant, CAa turned out to be higher for /a/ vs. /i/ word-initially and for /i/ vs. /a/ intervocalically and word-finally, while contextual /u/ caused /l/ to show the lowest CAa value in all three word positions (see figure 4b above, top left and middle graphs). Statistical results for CAa and CPa indicate that Valencian /l/ is more anterior word-finally than word-initially, presumably because the consonant is somewhat darker in the former position than in the latter (see ***(b)*** below). Vocalic effects are associated mostly with rounding, which suggests that placing the apicoalveolar closure further back may help implement the lip rounding gesture for /u/. This action may be both effective at the articulatory level (i.e. backing the tongue tip may leave the lips freer to round and protude) and at the acoustic level (i.e. front cavity lengthening may contribute to the lowering of F3 and other formant frequencies).

(b) Qp shows significant main vowel effects for /i/ > /u/ > /a/ ($F(1, 34) = 129.62$, $p < 0.001$), significant position-dependent effects varying in the progression intervocalic > word-initial > word-final ($F(2, 68) = 95.50$, $p < 0.001$) and significant vowel context x position interactions ($F(1, 34) = 47.02$, $p < 0.001$). According to table 4 and figure 4b (top right) above, vowel-dependent effects differ according to word position, i.e. /i, u/ > /a/ word-initially, /i/ > /u/ > /a/ intervocalically and /i/ > /a, u/ word-finally. Moreover, position-dependent differences in Qp are not the same in all vowel contexts, i.e. Qp varies in the progression intervocalic > word-initial, word-final for /i/, word-initial > intervocalic, word-final for /a/, and word-initial, intervocalic > word-final for /u/.

These data reveal the existence of more Qp coarticulation intervocalically than word-initially and word-finally, and differences in coarticulation type between the two latter positions (i.e. vocalic effects occur in tongue height word-initially and in tongue fronting word-finally). In addition, word-final /l/ is produced with less tongue dorsum raising, and is thus more velarized or pharyngealized, than word-initial /l/ in the context of /a, u/.

(c) F1 shows significant main vowel effects for /a/ > /i, u/ ($F(2, 68) = 329.13$, $p < 0.001$), significant position-dependent effects varying in the progression word-finally > word-initially ($F(2, 68) = 6.44$, $p < 0.05$) and significant position x vowel context interactions ($F(4,136) = 20.84$, $p < 0.001$). All three positions exhibit a higher F1 frequency for low /a/ than for high /i/ and /u/ (see table 4, and bottom left graph in figure 4b). Position-dependent differences also hold depending on the contextual vowel involved, i.e. word-initial, word-final > intervocalic for /i/, intervocalic > word-initial, word-final for /a/, and word-final > word-initial, intervocalic for /u/.

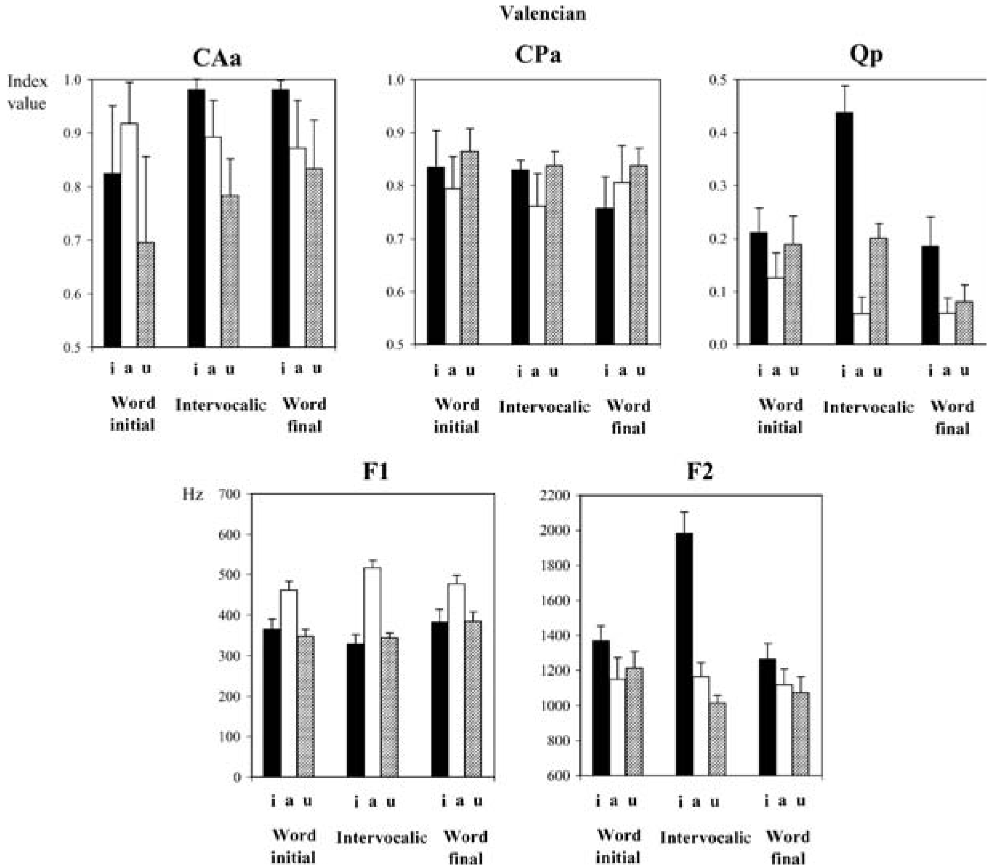


Figure 4b Mean CAa, CPa, Qp, F1 and F2 values for clear /l/ in Valencian as a function of position and vowel context. Data have been averaged across repetitions and speakers. Standard deviations are also given.

ANOVAs on the F2 data yielded significant main vowel effects for /i/ > /a, u/ ($F(2, 68) = 196.69$, $p < 0.001$), significant position-dependent effects varying in the progression intervocalic > initial > final ($F(1, 34) = 45.25$, $p < 0.001$) and significant position x vowel context interactions ($F(1, 34) = 163.19$, $p < 0.001$). As revealed by table 4 and figure 4b (bottom right graph), vowel-dependent differences are not the same word-initially and word-finally (/i/ > /a, u/) as intervocalically (/i/ > /a/ > /u/), and position-dependent differences may change depending on whether the contextual vowel is /i/ or /u/ (intervocalic > word-initial > word-final for /i/, word-initial > word-final > intervocalic for /u/).

In summary, Valencian /l/ allows effects in vowel opening (F1) and in vowel fronting (F2) in intervocalic position and, to a smaller degree, at word edges. Moreover, the lateral appears to be more velarized word-finally than word-initially since F1 is higher in the former position than in the latter while F2 shows the opposite relationship.

4 Discussion

4.1 Articulatory and acoustic properties

EPG data reported in the 'Results' section above show that dark /l/ in Majorcan is articulated with a more anterior (dentoalveolar) and less variable closure location than clear /l/ in

Valencian. Differences in closure fronting are consistent with the presence of a higher F3 in the former dialect than in the latter, and may be attributed to the need to fulfil velarization and laterality requirements simultaneously. The two varieties of /l/ appear to be produced with the tongue tip in both Catalan dialects, and do not differ regarding contact retraction at the back closure area and closure extent. Apicality for /l/ in Valencian is not in accordance with data for other languages and dialects showing a more widespread closure for clear /l/ next to high vowels (e.g. German data in Recasens et al. 1996, and Italian data in Recasens & Farnetani 1990). Continuous closure fronting and F3 lowering for Valencian clear /l/ in sequences with /u/ appears to be associated with lip rounding and is in support of the notion that this variety of /l/ is not highly constrained. Consistently with dialect-dependent differences in degree of darkness, /l/ vocalization may take place in Majorcan but not in Valencian. In contrast to American English data summarized in the 'Introduction' section, this vocalization effect may occur syllable-initially rather than syllable-finally.

As expected, clear /l/ is produced with more tongue dorsum raising and fronting, and shows a much higher F2 than dark /l/, mostly so in the case of /ili/. In contrast to other dialects with clear /l/, formant frequency data suggest that Valencian clear /l/ undergoes some velarization or pharyngealization in the intervocalic sequence /ala/. Vocalic effects in degree of dorsopalatal contact are more extensive in Valencian than in Majorcan and vary in the same progression as other dialects and languages, i.e. mostly in vowel height or in vowel fronting (dark /l/) and in vowel height and fronting (clear /l/).

In agreement with data reported in previous studies dealing with the two varieties of /l/, closure durations were found to be shorter for clear /l/ than for dark /l/. The two consonant types also differ regarding the relative timing between closure and voicing in word- and utterance-final position, i.e. voicing offset occurs at /l/ release or shortly after it in Valencian and before /l/ release in Majorcan. The scenario for Majorcan differs from that for other dialects, such as American English, exhibiting a strongly dark /l/ realization in that closure onset may not take place after voicing has ceased (see 'Introduction'). No dialect-dependent differences were found to hold word-initially, i.e. voicing begins during the second half of the closure period for both types of /l/ in Valencian and Majorcan. This was the predicted behavior for dark /l/ since this consonantal realization is known to involve gestural anticipation but not for clear /l/ for the production of which voicing and apical closure were expected to occur simultaneously.

Overall, the articulatory and acoustic characteristics of /l/ in the two Catalan dialects under analysis conform to those for strongly dark /l/ and clear /l/ in general. There are a few relevant differences, however, which are consistent with the view that darkness in /l/ proceeds gradually rather than categorically: Valencian clear /l/ appears to be essentially apical, partly voiceless utterance-initially, and prone to become dark in favorable vowel contexts; on the other hand, closure for Majorcan dark /l/ in syllable-final position is stable and closely timed with voicing.

4.2 Positional characteristics

In agreement with data for the two types of /l/ in other languages, the present investigation reports more coarticulatory sensitivity at the place of articulation and at the tongue dorsum for clear /l/ in Valencian than for dark /l/ in Majorcan.

Results also indicate that /l/ is not necessarily darker syllable-finally than syllable-initially and thus that position-dependent degrees of velarization are not universal. Thus, consistent with data for languages and dialects exhibiting a very dark variety of /l/ (see group ***(a)*** in section 1.3), Majorcan /l/ shows no substantial articulatory and acoustic differences (in tongue dorsum contact, closure location, F2 and F1) at the two word edges. Differences in alveolar contact size and closure duration for this variety of /l/ often decrease in the progression word-initially > word-finally > intervocalically, and may be taken as evidence for articulatory strengthening in initial position and, less so, in final position.

Contrary to the scenario for Italian, French and Spanish, data for Valencian suggest that clear /l/ may be darker syllable-finally than syllable-initially. Thus, in comparison to the phonetic realization in word-final position, word-initial /l/ in Valencian is less advanced, exhibits more dorsopalatal contact, and has a lower F1 and a higher F2. This scenario suggests a revision of the classification proposed in section 1.3 of the 'Introduction' section such that dialects with clear /l/ in group ***(c)*** be subdivided into two groups, i.e. a group allowing for a single allophone in initial and final position (Spanish, French) and another group, exhibiting a somewhat darker allophone word-finally than word-initially (Valencian).

The possibility that dark /l/ and clear /l/ may show one or two positional allophones, depending on the dialect taken into consideration, cannot be easily accounted for on production grounds. Differences in articulatory constraint for dark /l/ between Russian or Leeds British English, on the one hand, and Eastern Catalan or Newcastle British English, on the other hand, may explain why the tongue body does not undergo raising and fronting during the production of word-initial /l/ in the former dialectal group. This rationale cannot explain, however, why languages and dialects with clear /l/ other than Valencian do not exhibit two positional allophones in spite of the fact that this consonantal variety is produced with a relatively unconstrained tongue body (see, however, the situation for German /l/ in Recasens et al. 1995, 1996). The behavior of Valencian clear /l/ is more in accordance with the expected difference in degree of darkness as a function of position. In addition to prosodic factors (e.g. utterance-final strengthening), the pattern specifiying that dialects should exhibit one or two positional allophones of /l/ appears to be, to a large extent, part of the speaker's phonology and thus acquired as a rule during the language acquisition process.

Regarding vowel coarticulation, dark /l/ was found to be highly resistant to vocalic effects in closure location, dorsopalatal contact and F1 and F2 frequency in word-initial position and, less so, in word-final position. On the other hand, clear /l/ shows vowel effects in all positions, but less Qp and F2 coarticulation word and utterance-initially and word- and utterance-finally than intervocalically. This finding is consistent with the hypothesis that dialects with a strongly dark /l/ type should not exhibit two positional allophones, and in support of articulatory strengthening effects at the word edges. Similar degree of coarticulation resistance word-initially and word-finally are consistent with differences in articulatory prominence as a function of word position. It may be thus concluded that, for the dialects under investigation in the present paper and contrary to the scenario for palatal consonants (see 'Introduction'), initial /l/ is prone to resist the influence of the following vowel.

Effects in place of articulation and lip rounding from /u/ on /l/ may account for an increase in degree of darkness for /ul#/ in Majorcan, and for more closure retraction for /#lu/ in Majorcan and for /#lu/, /ulu/ and /ul#/ in Valencian. It thus appears that the implementation of lip rounding for /u/ during /l/ is facilitated by closure retraction, and that the tongue body position for both /u/ and dark /l/ are highly compatible.

Data for Majorcan, Valencian and other languages and dialects indicate that coarticulation for /l/ is dependent on the production constraints for the consonant and on positional requirements. Differences in degree of articulatory constraint for /l/ may account for the finding of more coarticulation word-initially than word-finally in dialects where dark /l/ exhibits two positional allophones (e.g. Eastern Catalan, British English RP), and for comparable amounts of word-initial and word-final coarticulation in dialects exhibiting a strongly clear /l/ type in both positions (e.g. Spanish, French). Word-initial strengthening may explain why, in comparison to word-final /l/, word-initial /l/ may be somewhat more resistant in dialects where the consonant is equally dark in both positions (e.g. Majorcan Catalan), and more or equally resistant in dialects where clear /l/ is clearer word-initially than word-finally (e.g. Valencian).

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