LINGUISTIC PHONETICS: A LOOK INTO THE FUTURE

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ABSTRACT

This paper exemplifies the need for collecting extensive experimental data on the language-dependent articulatory and acoustic characteristics of vowels and consonants. It reports data on constriction location for (alveolo)palatal consonants, and on the F2 frequency for allophonic realizations of different varieties of /l/, in several language groups.

Keywords: palatal consonants, darkness degree in /l/, linguopalatal contact patterns, F2 frequency

1. INTRODUCTION

We have at present a good deal of knowledge about sound inventory types [19], but are in need of more data on the articulatory and acoustic characteristics of phonetic categories in the world's languages along the lines of work carried out by Ladefoged and colleagues [17]. The collection of experimental data on the phonetic properties of vowels and consonants produced in different contextual and positional conditions by speakers of a considerable number of languages should contribute to improve our knowledge about the typological possibilities, production mechanisms and allophonic patterns for specific sound types. This information should help us reach a more thorough understanding of the adaptation mechanisms between consecutive phonetic segments in spoken sequences, and of the evolutionary paths for related sound changes.

A relevant issue in this respect is whether phonetic data reported in experimental studies are truly language-specific or else should be attributed to speaker-dependent anatomical properties or production strategies. This word of caution is all the more justified since speech production data are often gathered from a relatively small number of subjects and are not normalized for speaker-dependent differences. It should be said, however, that attempts to relate the articulatory characteristics of speech sounds to the speakers' vocal tract shapes have not been too successful. Thus, no clear relationship was found to hold between linguopalatal contact size and palate shape for a set of vowels and consonants produced by twenty speakers of four different languages, and for nine consonants produced by fifteen speakers of three Catalan dialects, i.e., it was not generally the case that speakers exhibiting domeshaped palates always had more lateral tongue contact than speakers with flatter palates [3, 28]. It may be that the relationship of interest becomes relevant for specific sound classes rather than for others. Thus, in the Catalan study just referred to, dorsopalatal contact size turned out to be correlated with palate height only when consonants of the (alveolo)palatal place of articulation in one of the three dialects subjected to investigation (Majorcan) were taken into consideration. It has also been shown that French speakers use different strategies for the articulation of /ʃ/, i.e., tongue retraction and no tongue dorsum elevation for some speakers, and tongue shape adjustment and tongue dorsum elevation for others [35].

Independently of whether speakers differ or not in the way they produce specific sound types, languages and dialects may select different articulatory patterns for vowels and consonants. This has proved to be the case for lip rounding in vowels [18], for the main articulator and place of articulation for dental and alveolar consonants [6], for the distribution of vowels in the vowel space [10], for fricative spectra [22], for vowel nasalization [4] and for stop voicing [16]. This paper contributes to the achievement of a more accurate knowledge of the language-dependent characteristics of speech sounds through the analysis of differences in closure and constriction location for (alveolo)palatal consonants, and in darkness degree and allophonic distribution for the alveolar lateral /l/.

2. (ALVEOLO)PALATAL CONSONANTS

In order to investigate the existence of language-dependent differences in the articulation of (alveolo)palatal consonants, a linguistic survey of closure and constriction locations has been carried out for the fricatives /ɕ/ and /ç/, the lateral /ʎ/, the oral stop /c/ (also /ɟ/), and the nasal stop /ɲ/. This literature survey includes linguopalatal contact data obtained by means of static palatography and electropalatography (EPG), as well as sagittal lingual configuration data obtained by means of cineradiography (X-ray) and magnetic resonance imaging (MRI). Overall, data for 238 consonant realizations produced by speakers of different languages and dialects have been analyzed (see Table 1). The target consonants occur mostly in a low vowel context, and have phonemic or a well-defined allophonic status in the languages under investigation.

Table 1: Number of items subjected to analysis classified according to consonant and language group. See text for details. Cont= linguopalatal contact data; config= sagittal tongue configuration data.

		ɕ	ç	ʎ	c	ɲ
A	cont	0	0	42	14	66
	config	0	0	5	1	8
B	cont	1	5	2	4	2
	config	0	8	0	1	0
C	cont	2	0	3	13	11
	config	5	0	1	5	7
D	cont	0	0	0	1	2
	config	0	0	0	1	0
E	cont	0	0	2	2	2
	config	0	0	0	0	0
F	cont	9	0	0	1	3
	config	4	0	0	0	0
G	cont	0	0	4	0	0
	config	1	0	0	0	0
Totals	cont	***12***	***5***	***53***	***35***	***86***
	config	***10***	***8***	***6***	***8***	***15***
	all	***22***	***13***	***59***	***43***	***101***

Languages and dialects have been classified into groups A through G as follows (not all the literature references from which the articulatory data have been taken are mentioned below):

[A] Romance (Eastern and Majorcan Catalan, Standard and dialectal French, Tuscan and Northern Italian, Lenguadocian and Gascon Occitan, European and Brazilian Portuguese, Romansh, Castilian and Argentinian Spanish) [9, 14, 20, 30, 33];

[B] Germanic (German, Icelandic, Swedish) and Irish Gaelic [7, 24, 33];

[C] Slavic (Czech, Polish, Slovenian) and Hungarian [1, 12, 13, 15];

[D] African (Ngwo, Ibibio, and the Malagasy Austronesian language [5, 17, 26, 32]);

[E] Australian (Arrernte) [34];

[F] Eastern Asian (Standard, Hakka and Xiangxiang Chinese, Japanese) [21, 37]);

[G] Greek, Basque and Abkhaz.

The analysis criteria of the linguopalatal contact data are described next. Regarding the static palatography data, linguopalatal contact percentages were calculated at four equidistant horizontal lines traced across the palate contact surface at the alveolar, postalveolo-prepalatal, mediopalatal and postpalatal zones. As for the electropalatographic data, contact percentages were calculated for the rows of electrodes 2, 4, 6 and 8 of the artificial palate which are located in the same four articulatory zones mentioned above. Tongue contact was taken to occur at those electrodes exhibiting more than 80% of activation across tokens.

Figure 1: Cross-linguistic linguopalatal contact percentages for laterals and stops (top graph) and for fricatives (bottom graph).

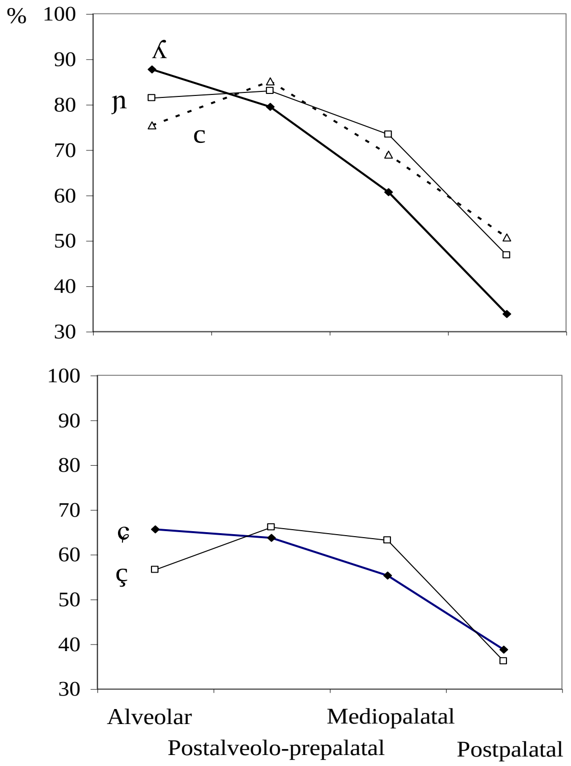


Figure 1 presents cross-language tongue contact percentages at the four articulatory zones for the consonants /ʎ, c, ɲ/ produced with a complete or central closure (top graph), and for the fricatives /ɕ, ç/ exhibiting a central constriction (bottom graph). In addition to the presence of less tongue contact for fricatives than for laterals and stops, the figure shows differences in constriction fronting varying in the progression /ʎ/ > /ɲ/ > /c/ (closure occurs at the alveolar zone for /ʎ/, at the alveolar and postalveolo-prepalatal zones for /ɲ/, and at the postalveolo-prepalatal zone for /c/), and /ç/ > /ç/ (a constriction maximum occurs at the alveolar zone for /ç/ and at the postalveolo-prepalatal and even mediopalatal zones for /ç/). Moreover, dorsopalatal contact size is less for /ʎ/ than for /c, ɲ/ and for /ç/ than for /ç/. The data for /ʎ, c, ɲ/ reveal that manner of articulation may play a relevant role in closure placement and degree of dorsopalatal contact. Thus, /ʎ/ is more anterior and exhibits less palatal contact than /c, ɲ/ presumably in order to facilitate the formation of one or two openings at the sides of the oral cavity for the passage of airflow. On the other hand, /ɲ/ is slightly more anterior than /c/ perhaps in line with differences in intraoral air pressure buildup between the two consonants, i.e., the air pressure level is higher for the oral stop than for the nasal stop.

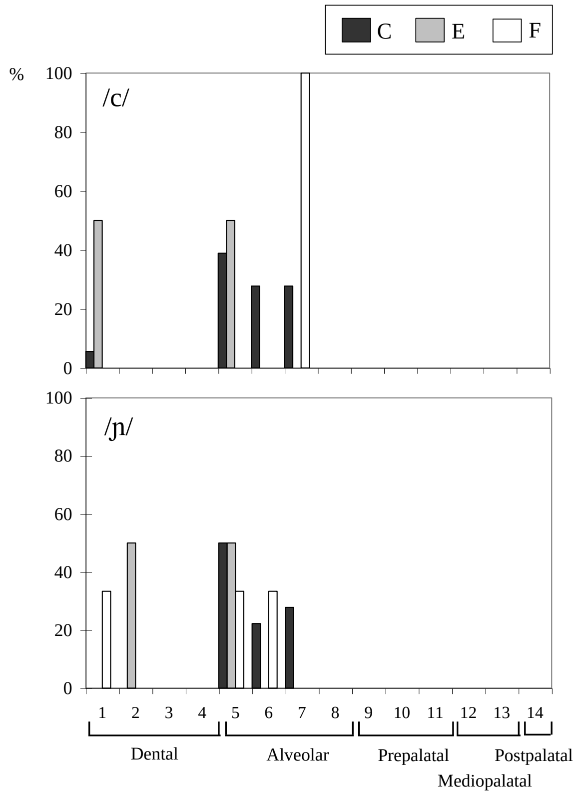
Language-dependent differences in frequency of occurrence of the closure location for the consonants /ʎ, c, ɲ/ were computed from the linguopalatal contact and sagittal tongue configuration data. Closure was taken to occur at the dental, alveolar, prepalatal, mediopalatal or postpalatal articulatory zones according to criteria described elsewhere [25]. In the linguopalatal contact patterns, dental contact was assigned to those contact patterns showing a complete closure at the frontmost alveolar zone.

Data for /ʎ/ revealed no substantial language-dependent differences. Thus, the lateral was found to be dental or alveolar, and to involve additional back central contact, in practically all language groups for which data had been collected (A: Romance, B: Germanic, Irish; C: Slavic; E: Australian).

Closure location for the stops /c/ and /ɲ/ may differ from one language group to another. Figures 2 and 3 present differences in closure location for the two consonants as a function of the language groups A through F. In the figures, the subdivisions on the horizontal axis correspond to different contact areas: in the case of the dental zone, closure is dentoalveolar in 1, dentoalveolo-prepalatal in 2, dentoalveolar, prepalatal and mediopalatal in 3, and takes place over all five articulatory zones in 4; as for the alveolar zone, closure is exclusively alveolar in 5, alveolo-prepalatal in 6, alveolar, prepalatal and mediopalatal in 7, and occurs over the whole palate surface in 8; as for the prepalatal zone, closure is prepalatal in 9, prepalato-mediopalatal in 10 and prepalatal and medio-postpalatal in 11; regarding the mediopalatal zone, contact occurs at the mediopalate in 12 and at the mediopalate and postpalate in 13; finally, central contact takes place exclusively at the postpalatal zone in 14.

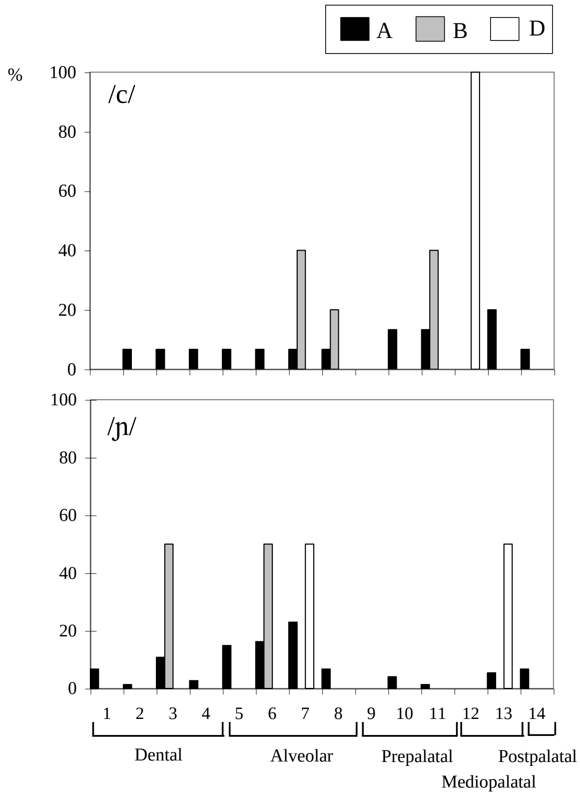
Taking /c/ as reference, Figure 2 (top) shows that the consonant is articulated exclusively at the alveolopalatal or more anterior articulatory zone in the Slavic (C), Australian (E) and East Asian (F) languages. On the other hand, Figure 3 (top) reveals that the oral stop closure takes place exclusively at the palatal zone in the African languages (D). Other languages may show the alveolopalatal and palatal articulatory patterns, i.e., Irish (B), as well as those Romance dialects where the stop is an allophone of /k/ before a front vowel and also before /a/, i.e., Majorcan Catalan [30] and Parisian French [33] (A).

Figure 2: Linguopalatal contact percentages for /c/ (top) and /ɲ/ (bottom) as a function of the language groups C, E and F. See text for details.



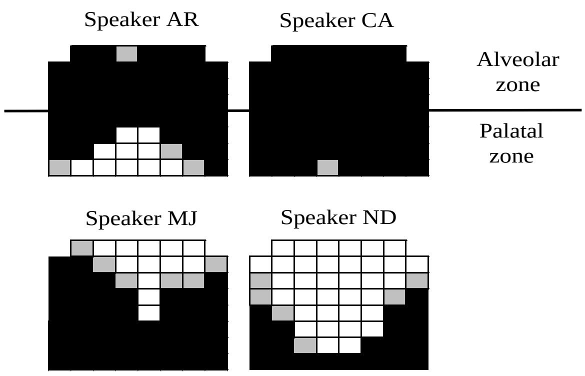
This range of linguopalatal contact patterns is illustrated in Figure 4 for the Majorcan Catalan speakers AR, CA, MJ and ND. Each contact pattern shows 62 squares which correspond to the electrodes placed on the surface of the artificial palate. The 62 electrodes are grouped into eight rows such that the four anteriormost rows (at the top of the palate graphs) belong to the alveolar zone while the four rearmost rows (at the bottom of the palate graphs) belong to the palatal zone. Moreover, the two frontmost rows of the alveolar zone are placed at the front alveolar area and the two backmost ones at the postalveolar area; as for the palatal zone, the four rows of electrodes are located, proceeding from front to back, at the prepalate, mediopalate and postpalate. Electrodes are marked in black if activated more than 80% of the time across tokens, in grey if activated 40-80% of the time, and in white if activated less than 40%. In the figure some speakers show an alveolopalatal closure with little or much contact in front and behind the postalveolo-prepalatal zone (AR, CA), and others a purely palatal articulation involving more or less front contact (MJ, ND).

Figure 3: Linguopalatal contact percentages for /c/ (top) and /ɲ/ (bottom) as a function of the language groups A, B and D. See text for details.



Another relevant point to be made is that languages tend to exhibit the same closure location for the two stop consonants /c/ and /ɲ/. According to the two graphs of Figures 2 and 3, an alveolar and/or alveolopalatal realization of /ɲ/ prevails in languages where /c/ is also alveolar and/or alveolopalatal, i.e., in Slavic, Australian and East Asian languages (groups C, E, F), as well as in the Romance languages (group A). On the other hand, a palatal realization of /ɲ/ occurs in linguistic domains where the oral stop is palatal, i.e., in African languages (group D) as well as in those Romance dialects where the oral stop is an allophone of /k/ (group A). Thus, in Majorcan Catalan, /ɲ/ is alveolopalatal or palatal in the case of speakers exhibiting, respectively, an alveolopalatal or palatal realization of the oral stop allophone (e.g., [c] and /ɲ/ are alveolopalatal for speaker CA and postpalatal for speaker ND; see Figure 4). I have only failed to find this symmetrical relationship in Irish where, while /c/ may be alveolopalatal or purely palatal, /ɲ/ appears to be essentially alveolopalatal [33].

Figure 4: Linguopalatal contact patterns for the front allophone [c] of /k/ in Majorcan Catalan as realized by four speakers. Data correspond to the word and utterance initial position before /a/ (seven tokens). See text for details.



It may be concluded that closure location for /c/ is dialect-dependent and that its place of articulation tends to be transferred to /ɲ/. In view of the alveolopalatal realization of these two stop consonants being much more frequent than the palatal one, one may ask whether there is a universal requirement for /c/ and /ɲ/ to be articulated at the alveolopalatal rather than at the palatal zone. It may be that speakers find it harder to form a stop closure at the hard palate with the dorsum of the tongue than at a more extensive area including the alveolar and palatal zones with a larger tongue region.

3. DARKNESS DEGREE IN /l/

There exists a fair amount of information about the articulatory properties of contextual allophones of vowels and consonants thanks to extensive work on segmental coarticulation carried out since the

1960s. Our knowledge about the articulatory properties of positional and prosodic allophones is more limited though relevant work on these allophonic types has been performed recently, e.g., research on segmental strength utterance initially and finally, and on segmental weakening in the syllable coda and intervocalic positions [2, 11, 36]. In my view, there is considerable need to investigate the allophonic patterns of interest in connection with the articulatory properties of phonetic segments in specific linguistic systems. I will illustrate this point by focusing on how allophonic patterns may vary with darkness degree in /l/ from one language to another.

Traditionally two different varieties of /l/ have been identified, i.e., clear and dark. Clear /l/ is articulated with a fronted and raised tongue body while dark /l/ involves some tongue predorsum lowering and postdorsum retraction. These production differences yield very different spectral configurations, i.e., /i/-like for clear /l/ and /u/-like for dark /l/. Acoustic and articulatory data show that the darkness scale in /l/ proceeds not categorically but gradually [26]. This point will be shown to hold for male speakers of several languages and dialects known to exhibit a clear variety of /l/ (see [A] below) and of other dialects with a dark variety of the consonant ([B]) (see [29] for references).

[A] French (6 speakers), Valencian Catalan (5 speakers), Spanish (7 speakers).

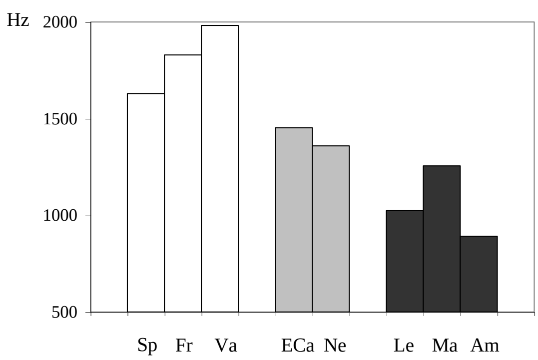
[B] Eastern Catalan (5 speakers), British English RP (4 speakers), Newcastle English and Leeds English (4 speakers each), Majorcan Catalan (10 speakers), American English (6 speakers).

F2 data will be used in order to elicit the degree of darkness in the alveolar lateral. This formant is known to be positively related to tongue body raising and fronting and thus inversely related to darkness degree [8], and its frequency falls within the 1600-2000 range for clear /l/ and the 800-1200 Hz range for dark /l/.

Darkness degree in /l/ will be analyzed next to the vowel [i] in the intervocalic sequence /ili/. As argued next, the presence of contextual [i] will allow us to ascertain the degree of darkness in the consonant since dark /l/ and /i/ are produced with antagonistic lingual gestures. In principle, the tongue dorsum should be more constrained for dark /l/ than for clear /l/ because it is involved in the formation of a back constriction for the former consonant variety as opposed to the latter. Therefore, the tongue body for clear /l/ should be placed in a similar position to that for /i/ while that for dark /l/ should not be affected much by the vowel tongue dorsum raising and fronting gesture. At the acoustic level, F2 for /l/ next to /i/ should stay at about 800-1200 Hz if the lateral is dark while approaching 2000 Hz if the lateral is clear. Moreover, these formant frequencies should vary accordingly in languages and dialects specified for different degrees of darkness in the alveolar lateral.

Figure 5 presents F2 data for the sequence /ili/ at the midpoint of the consonant for all languages and dialects subjected to investigation except for British English RP, for which no data were available. Judging from the height of the bars, three different varieties of /l/ may be identified: a strongly clear variety with an F2 frequency ranging between 1600 Hz and 2000 Hz in Spanish, French and Valencian Catalan; a moderately dark variety with an F2 ranging between 1300 Hz and 1500 Hz in Eastern Catalan and Newcastle English; a strongly dark variety exhibiting an F2 between 800 Hz and 1300 Hz in Leeds English, Majorcan Catalan and American English.

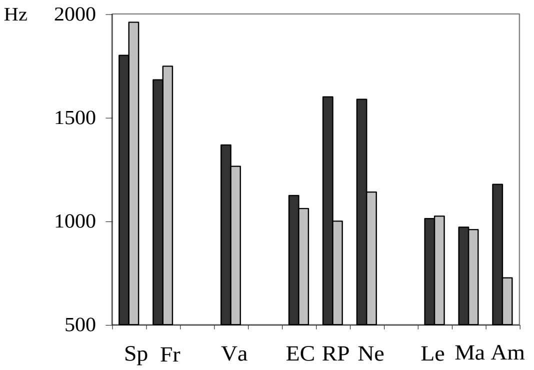
Figure 5: F2 frequency for /l/ in the sequence /ili/ in several language and dialects. Sp: Spanish; Fr: French; Va: Valencian Catalan; ECa: Eastern Catalan; Ne: Newcastle English; Le: Leeds English; Ma: Majorcan Catalan; Am: American English.



In order to investigate the allophonic patterns for these /l/ types, data for word/utterance initial and word/utterance final /l/ next to /i/ taken from the same literature sources referred to above will also be reported. An initial prediction is that strongly dark /l/ ought to exhibit similar strongly dark realizations initially and finally since it is highly constrained and therefore ought not to be affected much by context or position. This hypothesis is consistent with linguopalatal contact data showing no clear articulatory differences as a function of syllable position for other highly constrained lingual consonants, namely, fricatives and the trill or trill-like alveolar rhotic [27]. Moreover, to the extent that it is less constrained articulatorily, the moderately dark variety of /l/ ought to be more sensitive to differences in syllable position and it is therefore expected to show a clearer realization syllable initially than syllable finally. As for clear /l/, the expected trend is for position-dependent differences in F2 frequency to occur in line with the finding that relatively unconstrained consonants are produced with less dorsopalatal contact syllable finally than syllable initially [27].

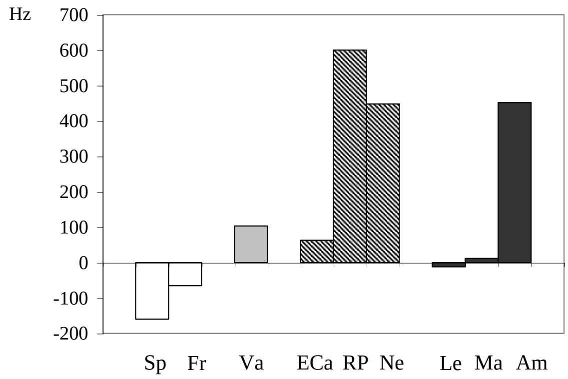
Figure 6 plots F2 values for initial and final /l/ in the case of all languages and dialects subjected to investigation. The same three groups identified in Figure 5 may also be identified in Figure 6, i.e., a group exhibiting a strongly clear variety of /l/ with a high F2 around 1700-2000 Hz (Spanish, French), another group showing an intermediate /l/ realization with F2 frequency values at about 1000-1600 Hz (Eastern Catalan, British English RP, Newcastle English), and a third group with a strongly dark variety of the consonant and thus a low F2 around 700-1200 Hz (Leeds English, Majorcan Catalan, American English). This time, however, Valencian Catalan cannot be grouped with those languages showing a strongly clear variety of /l/ since initial and final /l/ are not strongly but only moderately clear in this dialect. It seems then that /l/ may be characterized as moderately clear in Valencian Catalan, which suggests the need to establish four darkness varieties in /l/ in the languages and dialects taken into consideration: strongly clear, moderately clear, moderately dark and strongly dark.

Figure 6: F2 frequency for initial /l/ (black bars) and final /l/ (grey bars) in several language and dialects. See Figure 4 and body of the text for the language abbreviations.



In order to evaluate more precisely the position-dependent spectral differences for these four proposed varieties of /l/, the F2 frequency value for initial /l/ was subtracted from the F2 frequency for final /l/. The results of this subtraction operation have been plotted in Figure 7. According to the figure, the F2 frequency data for two out of three dialects with a strongly dark variety of /l/, i.e., Leeds English and Majorcan Catalan, conform to the initial hypothesis that no position-dependent differences ought to occur for this particular consonant variety. However, strongly dark /l/ in American English exhibits a much higher F2 frequency initially than finally, which does not accord with the hypothesis. On the other hand, data for languages and dialects showing moderately clear and moderately dark varieties of /l/ seem to conform to the initial expectation that F2 ought to be higher initially than finally. In any case, the size of this position-dependent difference is by no means homogeneous across languages, i.e., initial /l/ is much clearer than final /l/ in two English dialects (British English RP, Newcastle English) than in Eastern and Valencian Catalan. Finally, data for the languages with a strongly clear variety of /l/, i.e., Spanish and French, are not in agreement with the initial hypothesis that initial /l/ should have a higher F2 than final /l/ since the opposite difference (i.e., the presence of a higher F2 finally than initially) or practically no position-dependent differences appear to be taking place in this case.

Table 7: F2 frequency difference between initial and final /l/ in several language and dialects. See Figure 4 and body of the text for the language abbreviations.



To summarize, a trend for initial /l/ to exhibit a higher F2 than final /l/ appears to be at work for moderately dark and moderately clear varieties of /l/ but not for strongly dark /l/. However, not all dialects with a strongly dark variety of /l/ conform to this trend, and differences in darkness degree between the initial and final allophones of moderately dark and moderately clear /l/ may be much larger in some dialects than in others. In disagreement with our initial hypothesis, strongly clear /l/ behaves like strongly dark /l/ in failing to exhibit position-differences in degree of darkness. In this case, speakers appear to keep a relatively fixed tongue dorsum configuration in both initial and final positions. A clear realization of both initial and final allophones of /l/ seems to be available in other dialectal scenarios as well, e.g., Northern Irish [23].

4. DISCUSSION

Data reported in this paper reveal the existence of differences in place of articulation for (alveolo)palatal consonants among language groups. At this point it is hard to ascertain whether the place of articulation typology proposed in the present study can be extended to other languages. Regarding this issue, Table 1 shows that some language groups are underepresented, i.e., the number of items subjected to investigation was much higher for the Romance languages than for groups B through F, with the partial exception of group C. This scenario calls for the analysis of additional data on closure location for (alveolo)palatal consonants from the languages of Africa, Australia and Asia. More attention needs to be paid to several issues which have been identified in the present investigation, i.e., the extent to which the articulatory characteristics of specific consonants are dialect-dependent or speaker-dependent, as well as the articulatory symmetry relationship between /c/ and /ɲ/. Regarding the former aspect, our position is that, as indicated in section 1, while speaker-specific anatomical constraints may play a role, there are language-dependent differences in closure or constriction location which are essentially speaker-independent. As for the latter aspect, data from non-Romance languages need to be collected in order to verify whether stop consonants differing in manner of articulation, i.e., /c/ and /ɲ/, necessarily exhibit the same closure location or not.

Further research should elucidate whether the articulatory and acoustic characteristics of /l/ in languages and dialects other than the ones reviewed in this paper fall within the same four darkness categories which have been identified in section 3, i.e., strongly and moderately clear and strongly and moderately dark. Moreover, position-dependent differences for all these varieties of /l/ ought to be explored in detail. A crucial issue in this respect is to elicit the extent to which the allophonic patterns for the consonant are associated with its degree of articulatory constraint. Finally, data for the initial and final allophones of strongly clear /l/ reported in this paper suggest that speakers may constrain the tongue dorsum to a large extent during the production of this consonantal variety. This possibility calls for a reconsideration of the factors involved in lingual control in speech production.

The temporal implementation of the different varieties of /l/ needs to be investigated as well. In the first place, it would be of interest to explore the extent to which the degree of anticipation of the tongue body lowering and backing activity with respect to the apical raising gesture depends on the degree of darkness in /l/. Secondly, it is important to determine whether a trend for closure formation for dark /l/ to occur after the voicing period in prepausal position depends on darkness degree. While this characteristic has been shown to take place in American English [31], it does not seem to apply to Majorcan Catalan in spite of the two dialects exhibiting the same strongly dark variety of the consonant.

5. ACKNOWLEDGMENTS

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