FLAPPING IN UNCONSTRAINED ALVEOLARS

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ABSTRACT

Electropalatographic data for /n/, /ɾ/ and clear /l/ in two Catalan dialects reveal that all three consonants undergo continuous closure fronting after low and back rounded vowels in VCV sequences, next to these same vowels in postpausal and prepausal position, and next to labial and velar consonants in consonant clusters. It is argued that this flapping mechanism is associated with the low degree of tongue constraint involved in the production of the three alveolars.

Keywords: closure fronting, flapping, Catalan, electropalatography.

1. INTRODUCTION

Continuous closure or constriction fronting during consonant production has been reported to occur mainly for the alveolar flap (i.e., the American English articulation of /t, d/ in the words city, ladder) and for velar stops in specific vowel environments. Alveolar flaps are articulated with a rapid forward and downward movement of the tongue front starting at a relatively back location and contacting momentarily the palate on the way ([1, 3]). Tongue dorsum continuous motion for velars becomes most salient as the tongue is vigorously pressed against the palate, and has been attributed to the muscular forces involved and/or to overpressure behind the constriction [2].

Continuous closure fronting has also been found to hold for other alveolar consonants such as /n/ in the sequence /ono/ in German ([2]), and for the tap /ɾ/ and clear /l/ in Catalan according to preliminary linguopalatal contact data. In order to assess the validity of this finding, the present study will conduct an electropalatographic (EPG) investigation of /n/, /ɾ/ and clear /l/ in two Catalan dialects, i.e., Majorcan and Valencian.

The extent to which continuous closure fronting for these alveolar consonants is contextually conditioned will be explored. Tongue tip and/or blade forward movement could be triggered by tongue dorsum fronting in VCV sequences where V1 is less anterior than V2. Tongue dorsum activity cannot possibly account, however, for closure fronting in symmetrical VCV sequences or in VCV sequences where V1 is more anterior than V2. In this case, closure fronting may be associated with the fact that /n, ɾ, l/ are produced with a fast apical gesture, do not require a precise tongue body positioning and therefore, are relatively unconstrained. Explanatory arguments proposed for velar stop closure fronting (see above) cannot apply to alveolar closure fronting: the alveolar contact area is too small to involve considerable passive forces and the back cavity for alveolars is too long to allow for overpressure behind closure location.

In support of our hypothesis, highly constrained alveolars dark /ɫ/ and the trill /r/ showing simultaneous predorsum lowering and postdorsum backing exhibit little or no closure fronting in Catalan. Indeed, /ɫ/ may be maximally anterior and undergoes no changes in closure placement. On the other hand, closure fronting for /r/ occurs in favorable conditions only, i.e., in sequences where V1 is low or back rounded and V2 is front (e.g., /ari/), and towards closure offset in postpausal position where the trill is especially long.

2. METHODOLOGY

Continuous closure fronting was investigated for /n/ and /ɾ/ in Majorcan and Valencian, and for clear /l/ in Valencian but not in Majorcan where the alveolar lateral is strongly dark. Consonants were placed in intervocalic position (/VnV, VɾV, VlV/), utterance initially (/#n, #l/), utterance finally (/n#, ɾ#, l#/), preconsonantally in heterosyllabic clusters (/ɾC, lC/), and postconsonantally in tautosyllabic clusters (/Cɾ, Cl/). Data could not be acquired for /#ɾ/ since only the trill /r/ occurs utterance-initially, for /ɾ#/ in Majorcan since rhotics are not allowed word-finally in this dialect, for postconsonantal /n/ in tautosyllabic clusters since the alveolar nasal is not available in this case, and for /nC/ sequences where /n/ often assimilates to the C2 place of articulation in Catalan.

The analysis material appeared in a list of short sentences (/VnV, VlV, #l, l#, Cl, VɾV, ɾ#, Cɾ, ɾC/) and in sentences elicited spontaneously in a story telling task (/VnV, #n, n#, VlV, lC/). Consonants were flanked by a varied range of vowels, i.e., stressed /i, e, ɛ, a, ɔ, o, u/ (Majorcan, Valencian), unstressed /i, ə, u/ (Majorcan), unstressed /i, e, a, o, u/ (Valencian). Clusters had a labial or a velar consonant not interfering with the tongue front gesture for the liquid.

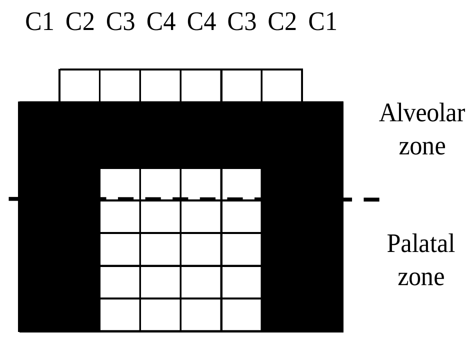
Five Majorcan speakers (AR, BM, MJ, ND, CA) and five Valencian speakers (JM, VB, MS,VG, AV) recorded seven times the sentence list. The spontaneous speech sample was recorded by all five Majorcan speakers and by the Valencian speakers JM, MS and VG. Linguopalatal contact and acoustic data were gathered synchronously with the Reading EPG-3 system every 10 ms using artificial palates equipped with 62 electrodes. The acoustic data were digitized at 10 kHz.

Closure location was measured at consonant onset, midpoint and offset on linguopalatal contact patterns. Data were collected placing a cursor on simultaneous EPG, spectrographic and waveform displays with the MultiSpeech 3700 program of Kay Pentax. EPG contact patterns show 62 electrodes distributed into eight horizontal rows and four vertical columns at each half of the palate surface (see Figure 1). In the figure (which corresponds to a single repetition of intervocalic /n/), filled electrodes have been contacted by the tongue while empty ones have not.

Closure location was identified with the row showing contact on all its electrodes, on all its electrodes except for a central one, or on its two central electrodes only. If two rows complied with these criteria, closure location was taken to occur at the average row value, e.g., at 1.5 if those two rows were rows 1 and 2. A value of 0.25 was added to or substracted from the closure location value in case that the row in front or behind the maximally activated row showed contact on all electrodes except for the two central ones.

In order to evaluate the degree of closure fronting, closure location values at consonant offset were subtracted from those at consonant onset. Differences could be positive (whenever there was closure fronting), negative (if closure underwent retraction instead of fronting) or zero (if there was neither closure fronting or backing). Differences for the read speech material were submitted to statistical analysis after transforming the negative values to zero. One-way ANOVAs were carried out on the /VnV/ data for each dialect and on the /VɾV/ data for Majorcan, with 'vowel' as a factor. This independent variable was associated with V1 quality in VCV sequences and with the only vowel in #CV and VC# sequences, and had the three levels 'front' (/i, e, ɛ/), 'low' (/a, ə/) and 'back rounded' (/ɔ, o, u/). Two-way ANOVAs were also run on the data for /VlV, #l, l#, VɾV, #ɾ/ in Valencian, with the independent variables 'vowel' ('front', 'low', 'back rounded') and 'position' ('intervocalic', 'initial', 'final'). Again the 'vowel' factor was related to differences in V1 quality in VCV sequences. The significance level was set at $p < 0.05$.

Figure 1: EPG contact pattern with row (R) and column (C) numbers.



3. RESULTS

3.1. Closure fronting

Tables 1 and 2 display differences in closure location in number of rows between consonant onset and offset for the VCV sequences (Table 1) and for the #CV, VC# sequences (Table 2) in read and spontaneous speech averaged across repetitions and speakers. Thus, for example, a value of 2.00 for Valencian /oli/ in Table 1 means that closure fronting occurs over two rows. In the tables, differences between 0.4 and 0.8 are given in boldface and those exceeding 0.8 are given in boldface and underlined. Segmental sequences showing no numerical values were not available for analysis.

VCV data in Table 1 reveal that the size and frequency of occurrence of the closure fronting motion varies with V1 in the progression back rounded > low > front. There is little or no fronting in VCV sequences starting with a front vowel; in fact, values may often be negative in this case. Fronting occurs more frequently and travels a larger distance in VCV sequences with a low V1 and, even more so, in those with a back rounded V1. Values for utterance-initial and utterance-final consonants in Table 2 also reveal largest differences for the back rounded vowel condition.

The extent and frequency of occurrence of closure fronting also vary with the consonant. V1-dependent fronting effects in VCV sequences hold clearly for /n/. ANOVAs for read /VnV/ sequences yielded a main effect of 'vowel' both for the Majorcan data ($F(2,185) = 7.67$, $p < 0.001$) and for the Valencian data ($F(2,229) = 22.43$, $p < 0.001$). According to post-hoc tests, V1-dependent differences turned out to vary significantly in the progression back rounded> front, low in Majorcan and back rounded > low > front in Valencian.

Analogous contextual effects hold for VCV, #CV and VC# sequences with clear /l/ in Valencian. ANOVAs yielded a main effect of 'vowel' ($F(2,312) = 14.76$, $p < 0.001$) and 'position' ($F(2,312) = 23.74$, $p < 0.001$), and a significant 'vowel' x 'position' interaction ($F(4,312) = 7.5$, $p < 0.001$). Differences decrease significantly as a function of vowel context (back rounded > low > front), and are significantly larger at the utterance edges than intervocalically (VC#> #CV > VCV) though sequences such as /ali, oli, ola, ula/ also exhibit considerable fronting.

Regarding /ɾ/, VCV closure fronting was found to be significantly more extensive when V1 is back rounded than when it is front or low in Majorcan ($F(2,64)=18.18$, $p <0.001$). There is little fronting in Valencian, i.e., ANOVAs yielded no main effect of 'vowel' or 'position' and no 'vowel' x 'position' interaction in this case.

Postconsonantal and preconsonantal liquids may also exhibit some closure fronting. Fronting in clusters is less obvious for the rhotic (i.e., values for /Cɾ, ɾC/ are generaly below 0.5) than for /l/ (i.e., values may now be about 1.25 or higher).

3.2. Place of articulation

Closure fronting for /n, ɾ, l/ occurs irrespective of place of articulation. Figure 2 displays closure movement trajectories for these consonants in the read VCV sequences. According to the figure, closure fronting applies in Majorcan and Valencian in spite of the fact that there is less articulatory space available in the latter dialect (where consonant closure may occur between rows 1 and 3) than in the former (where closure may take place between rows 1 and 4).

Table 1: Degree of closure fronting in number of rows for intervocalic /n, ɾ, l/ as a function of vowel context, dialect (Maj= Majorcan, Val= Valencian) and speech style (R= read, S= spontaneous). The symbols e and o correspond to /e, ɛ/ and /o, ɔ/, respectively.

	n				ɾ		l	
	Maj		Val		Maj	Val	Val	
	R	S	R	S	R	S	R	S
Front V1								
i_i		0.00					**0.47**	0.17
i_e		0.00	0.23	-0.25				
i_ə	0.13							
i_a		0.33	0.03	-0.75				0.25
i_o	-0.33	-0.25		0.25				
i_u	-0.17							-1.00
e_i			0.30	-0.17	0.17	0.30		0.25
e_e			0.11	-0.25				0.00
e_ə	**0.49**	0.00						
e_a			-0.30	-0.17				0.11
e_o				0.08				
e_u				-0.58				
Low V1								
ə_i	-0.06	0.09						
ə_e		-0.50						
ə_ə	0.36	0.18						
ə_a		**0.65**						
ə_o	0.10	-0.28						
a_i		**0.50**		**0.50**				**1.00**
a_e			**0.93**	**0.80**				**0.56**
a_ə		**0.50**						
a_a			0.26	-0.15	0.39	0.20	**0.40**	**0.72**
a_o		0.38	**0.40**	-0.13				0.31
Back V1								
o_i				**1.50**				**2.00**
o_e				**0.50**				
o_ə	**1.20**	**1.50**						
o_a		0.25	**1.00**	0.38				**2.00**
o_o	0.30	**0.67**	**0.40**					
u_i		**1.00**						
u_e			**0.93**	**1.38**	**1.22**	0.24		
u_ə		**0.91**						
u_a		**0.50**	**0.93**	**0.83**				**1.00**
u_o		**0.83**		**0.50**				
u_u							**0.50**	

Table 2: Degree of closure fronting in number of rows for postpausal and prepausal /n, ɾ, l/ as a function of vowel context, dialect (Maj= Majorcan, Val= Valencian) and speech style (R= read, S= spontaneous). The symbols e̲ and o̲ correspond to /e, ɛ/ and /o, ɔ/, respectively.

	n			**ɾ**	**l**
	Maj	Val		Val	Val
	S	R	S	R	R
Front V1					
#_i	-0.50		0.00		**0.71**
i_#			-0.33	-0.40	**0.44**
e_#	0.00			0.08	
Low V1					
#_a					**0.74**
a_#	0.00	0.20		0.20	**1.24**
Back V1					
#_o	-0.06		**0.50**		
#_u					**1.00**
o_#	**2.00**		**1.50**	0.33	
u_#					**1.64**

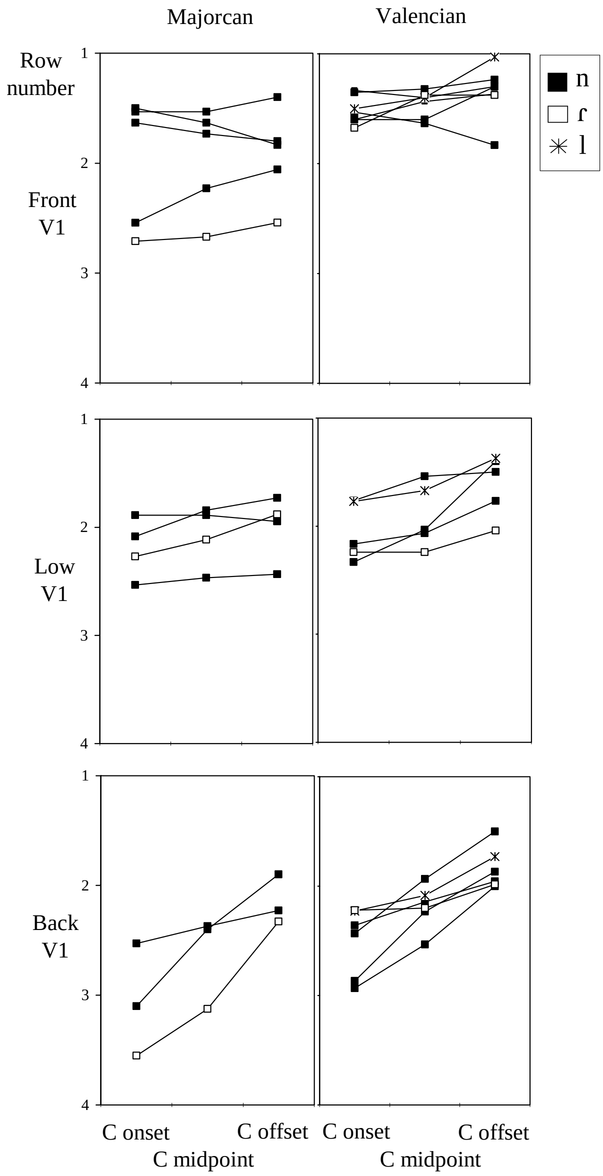
4. DISCUSSION

Data reported in this paper show continuous closure fronting effects for /n, ɾ, l/ in VCV, #CV and VC# sequences, and in clusters, in Majorcan and Valencian. Fronting occurs irrespective of closure location for the consonant, which is usually more anterior in Valencian than in Majorcan. It is least for the tap perhaps since this consonant is too short to allow for changes in closure location.

As a general rule, the degree of closure fronting in VCV sequences varies with V1 quality in the progression back rounded > low > front. Coarticulation studies also show that closure location for alveolars is more retracted in the context of /a, u/ vs /i/ but do not report any continuous closure fronting during the consonant.

As pointed out in the Introduction, the rationale for this closure fronting motion may be sought in the flexibility of the tongue front for unconstrained alveolars. An argument in favour of this interpretation is that closure fronting is not necessarily conditioned by tongue dorsum activity, i.e., tongue dorsum activity could account for closure fronting in clusters where V1 is more posterior than V2 but not in sequences where both vowels agree in fronting or where V1 is more anterior than V2. A flapping mechanism appears to be at work which does not seem to differ much from that reported for rhotics characterized as flaps in the literature.

Figure 2: Continuous closure fronting trajectories for read VCV sequences with /n, ɾ, l/ as a function of V1 and dialect.



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