Gradient weakening of syllable-final /s, r/ in Majorcan Catalan consonant clusters

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Abstract. *Electropalatographic (EPG) and acoustic data reveal that syllable-final /s/ and /r/ may undergo a gradual weakening process before voiced stops, nasals and laterals in Majorcan Catalan /sC/ and /rC/ clusters. It is argued that presumable phonetic changes occurring along this weakening continuum, i.e., /s/ rhotacism, regressive assimilation and elision, have no articulatory reality in most cases. In particular, perceived C1 assimilation and elision are often incomplete.*

1. Introduction

Syllable-final stops followed by a consonant undergo prominent changes in Catalan dialects, i.e., regressive assimilation in Majorcan and lenition in Valencian. Fricatives and rhotics are more resistant but show signs of instability as well. Thus, according to descriptive data for Majorcan in the literature (see below), /s/ behaves diffferently depending on the voicing status of the following consonant: voiceless /s/ stays unchanged before voiceless consonants, while voiced /s/ may undergo rhotacism, assimilation and elision before voiced consonants. All these changes could be accounted for in terms of articulatory reduction and are presumably associated with a decrease in intraoral pressure triggered by the voiced consonant following /s/. Such a decrease is expected to occur most often before laterals and nasals since these consonants allow continuous airflow out of the mouth or nose, respectively. This scenario differs from that for other languages where /s/ weakening through aspiration, glottalization and elision operate mainly before voiceless stops. The goal of this paper is to contribute to the understanding of changes affecting /s/ and /r/ in coda position before voiced consonants by looking at their realization in present-day Majorcan Catalan. This research is relevant to the understanding of the articulatory relationship between phonetic processes and of the role of contextual and non-contextual factors in their implementation.

A first research goal is to look into the contextual constraints on the application of /s/ weakening. The realization of Majorcan /s/ is entirely predictable before /z, ʒ/ (> [ddz, ddʒ]) and the trill /r/ (> [(r)r]). Previous studies agree in that the alveolar fricative undergoes optional rhotacism before other voiced consonants, and disagree as to whether complete assimilation applies systematically before a following lateral (e.g., /sl/> [ll]; Bibiloni, 1983) or optionally before a following lateral, nasal and /j/ (e.g., /sl, sn, sj/ > [ll, nn, jj]; Recasens, 1996, Wheeler, 2005). Historically, Majorcan has also undergone /s/

vocalization into [j] before a voiced consonant in several words (eima "consciousness" from Latin ADAESTIMARE, almoina "alms" ELEMOSYNA). Evidence in support of the application of these sound changes in the context of a voiced C2 may be found in other Romance dialectal domains, e.g., in Sardinian Logudorese where /s/ assimilates to a following nasal or liquid and undergoes rhotacism before /b, d(z), g, f, v/, and in Gascon where /s/ turns into [j] before any voiced consonant (Recasens, 2002). There is also widespread evidence that /s/ elision may operate before nasals, laterals and other voiced consonants, e.g., in Old French where /s/ effacement is documented earlier in île "island" INSULA than in fête "holiday" FESTA (Pope, 1934).

The alveolar rhotic appears to undergo analogous weakening processes in Majorcan /rC/ clusters. Thus, the final rhotic of infinitives assimilates to the initial lateral or nasal of a following clitic pronoun, and regressive assimilation occurs before /l/ in lexical items such as parlar "to speak" and perla "pearl" (i.e., /rl/ > [ll]; Bibiloni, 1983). Similar changes take place in other Catalan dialects, i.e., /r/ assimilation before /l/ and /n/ in the words parlar "to speak" and tornar "to come back" (Alguerese Catalan), and /r/ elision in the sequence per la "for the" (General Catalan) and word finally in the lexical items govern "government" (Alguerese) and dorm "he/she sleeps" (Southern Valencian zones). Moreover, frication may interfere with the articulatory and aerodynamic requirements for tapping or trilling and cause /rs/ to turn into [s], e.g., Catalan [ˈbosə] "handbag" from Latin BURSA.

A relevant question is whether articulatory reduction proceeds gradually rather than categorically such that one may find variable and poorly defined phonetic outcomes for coda /s/ and /r/ which cannot be easily ascribed to any of the sound changes just referred to. A related research issue is whether the elision of syllable final /s/ and /r/ in clusters must be preceded by other, less extreme weakening changes. If so, preconsonantal /s/ would undergo rhotacism or vocalization in the first place, rhotacized or vocalized /s/ would assimilate to the following consonant in the second place, and the resulting geminate could shorten thus causing any traces of /s/ to disappear. If no intermediate changes are at work, /s/ elision ought to take place through extreme reduction of the apical gesture, i.e., /sC/ > [^{s}C] > [C]. In any event, we expect to find instances of perceived but incomplete /s/ and /r/ assimilation and elision exhibiting articulatory traces of the apical raising gesture (Browman and Goldstein, 1992).

2. Method

Acoustic and electropalatographic (EPG) data were recorded and analyzed for the /sC, rC/ clusters in the sequences presented in Table I. Five Majorcan speakers (AR, BM, MJ, ND, CA) read seven times the 15 sequences in the table with the Reading artificial palate in place. Several clusters with a voiceless C2 were also recorded and analyzed for comparison. Sentence 13, which is possible in Majorcan but not entirely correct in Standard Catalan (it should be els deutes els cobr), was recorded by speaker CA only. Speaker BM's productions of sentence 10 and speaker ND's productions of sentence 12 were not subject to experimental analysis since these speakers often paused between the two consonants of the cluster /sl/. Regarding the clusters /sb, sd/, /b/ was basically produced as a voiced stop and /d/ could exhibit approximant and stop realizations. Acoustic and EPG data were also analyzed for the same clusters and for other clusters with C1=/s, r/ taken from a spontaneous speech database recorded by the same speakers (not all clusters were available for all speakers).

Linguopalatal contact patterns and several acoustic properties (frication noise, formant structure) for preconsonantal /s/ and /r/ were tracked on simultaneous waveform, spectrographic and EPG displays using MultiSpeech 3700 of Kay Elemetrics. As shown in Figure 2, electrodes on the EPG linguopalatal contact patterns are distributed into rows horizontally (from 1 to 8 starting at the dental zone at the top of the EPG pattern) and into columns vertically (from 1 to 4 on each half of the artificial palate). In the Results sections 3 and 4, we will refer to row 1 as dental or front alveolar, to rows 2 and 3 as centroalveolar and to row 4 as postalveolar.

(/sb/)	1. é**s b**ona tela	(“it is a good fabric”)
	2. toquen do**s b**alls	(“they play two dances”)
(/sm/)	3. l’avi é**s m**olt ric	(“my grandfather is very rich”)
	4. l’arbre é**s m**olt lluny	(“the tree is very far away”)
(/sd/)	5. l’amic é**s d**alt	(“my friend is upstairs”)
	6. l’amic é**s d**alt i no baixarà	(“my friend is upstairs and will not come down”)
	7. el pi**s d**e sota	(“the downstairs flat”)
	8. litre**s d**e llet	(“liters of milk”)
(/sn/)	9. jo els compte**s n**o els quadr	(“the expense accounts do not come out right according to my calculations”)
(/sl/)	10. les llavor**s l**es sembr	(“I sow the seeds”)
	11. les feine**s l**es concentr	(“I do all jobs at the same time”)
	12. aquestes pece**s l**es acopl	(“I fit these parts together”)
	13. les deute**s l**es cobr	(“I charge the debts”)
(/rn/)	14. un perill inte**rn**	(“an internal danger”)
(/rl/)	15. pa**rl**a zulú bé	(“he/she speaks the Zulu language correctly”)

Table I. Read sentences in Catalan orthography with the clusters under analysis in boldface.

3. Results (fricative clusters)

Both for the read and spontaneous speech material, /s/ exhibited a robust frication noise before all voiceless consonants. As for /sC/ clusters with a voiced C2, six /s/ weakening outcomes ***(a)*** through ***(f)*** were identified which will be characterized in sections 3.1, 3.2 and 3.3. Table II reports the occurrence of these six realizations of /s/ for all clusters and speakers. For some clusters, tokens exhibiting /s/ reduction may cooccur with tokens where the fricative clearly has some frication noise.

3.1 Approximant with or without friction

In outcome ***(a)***, the fricative is heard more or less successfully and exhibits an approximant-like realization with some low intensity noise overlaid on it. Frication is more salient when the lingual constriction is especially narrow (for speakers BM, MJ and ND), and may have an /r/-like quality (e.g., for the cluster /sb/ in the case of speakers BM and MJ). Preconsonantal /s/ may also exhibit a less salient frication noise and just some tongue contact at the two lateralmost columns of electrodes (see the waveform and spectrographic displays for [sb] in the upper left graph of Figure 1 and the EPG contact pattern in the left graph of Figure 2). The perceptual outcome for clusters in which /s/ is realized as a frictionless approximant involves the assimilation of /s/ to C2 or else /s/ elision, e.g., /sd/ may be heard as [(d)d], [(ð)ð] and /sn/ as [(n)n].

Clusters	**Weakening outcomes**	**Speaker AR**	**Speaker BM**	**Speaker MJ**	**Speaker ND**	**Speaker CA**
/sb/	***a***	1	1,2	1,2	1,2	sp
/sv/	***a***					sp
/sm/	***a***		3	3	3, 4	
/sd/	***a***	5,6,7,8,sp	5, 6,7,8,sp	5, 6,7,8	5, 6,7, 8,sp	5,6
/sn/	***a***			9, sp	9	
/sb/	***b***	1,2,sp				
/sm/	***b***	4				
/sb/	***c***				sp	
/sm/	***c***			4	3,sp	4
/sd/	***c***		7			
/sn/	***c***	9		9		
/sg/	***c***					sp
/sm/	***d***	3	4,sp			
/sn/	***d***		9			9
/sl/	***d***	10,11,12	11,12	10,11,12	10,11	10, 11, 12, 13
/sb/	***e***					1,2
/sm/	***e***					sp
/sd/	***e***					5,6,sp
/sm/	***f***					3
/sd/	***f***					5,7,8

Table II. /s/ weakening outcomes ***(a)*** through ***(f)*** for the 13 /sC/ sequences of Table I and for the spontaneous speech sequences («sp»).

3.2 No friction or formant structure

The alveolar fricative may lack a well-defined approximant period. It is often implemented through some contact fronting at the lateralmost column of electrodes (outcome ***(b)***) or some alveolar constriction (outcome ***(c)***), and through a decrease in amplitude in nasal clusters. Outcome ***(c)*** is illustrated in the upper right graph of Figure 1 and in the central graph of Figure 2.

In outcome ***(d)***, i.e., perceived /s/ elision, the fricative exhibits no approximant period and no specific articulatory configuration as a general rule. A decrease in amplitude at nasal murmur onset in the clusters /sm, sn/ (e.g., for speakers AR and BM) suggests, however, that complete /s/ elision is not necessarily at work in this case.

As shown in Table II, maximal /s/ weakening is triggered by nasals rather than by voiced stops (outcomes ***(b)*** through ***(d)***). Moreover, outcome ***(d)*** is practically the only option for the cluster /sl/.

3.3 Rhotacized /s/

Speaker CA allows for rhotic realizations of /s/ involving complete closure and no formant structure before voiced stops and nasals (outcome ***(e)*** in Table II). These realizations are articulated with some continuous fronting (from rows 3 or 4 to row 2 of the artificial palate), and trigger F3 lowering in the adjacent vowel and the insertion of a short epenthetic vocalic element between the two consonants of the cluster much in the same way as underlying /r/ in /rC/ clusters. Another possibility is for rhotacized /s/ to exhibit no closure but some central lingual constriction and some formant structure. Waveform, spectrographic and EPG displays for rhotacized /s/ may be found in Figure 1 (bottom graph) and in Figure 2 (right graph), respectively.

Other productions of preconsonantal /s/ by speaker CA have no /r/-like quality and show complete occlusion on the EPG and acoustic records (outcome ***(f)***). The EPG closure may be fixed at about row 2 in the centroalveolar zone, or else undergo continuous fronting from rows 2 or 3 to row 1. Analogously to ***(e)*** above, these realizations also occur before voiced stops and nasals and could be transcribed as [dm, dd] (/sm, sd/).

Inspection of data in Table II reveals that rhotacized realizations of /s/ alternate with approximant or fricative realizations for some sequences (sequences 5 and 6) but not for other (sequences 1 and 2).

4. Results (rhotic clusters)

According to our database, the cluster /rl/ in the word <u>parla</u> “he/she speaks” (sentence 15 in Table I) undergoes regressive assimilation and exhibits a fixed closure at the front or central alveolar rows 1 and 2 for some speakers (BM, MJ), but two perceptually distinct consonants and changes in alveolar constriction location from /r/ (more posterior) to /l/ (more anterior) for other speakers (AR, ND, CA). Regarding the /rn/ sequences, data from spontaneous speech reveal that /r/ assimilates to /n/ in production and perception for speaker CA; indeed, /rn/ sounds [nn] in the word <u>torna</u> “he/she returns” and related forms, independently of whether the alveolar closure remains fixed or exhibits continuous fronting as for /n/ in the sequence /ona/ in other words produced by the same speaker. A similar scenario applies to this speaker's productions of intern "internal" (sentence 14 in Table I). While also sounding assimilated, speaker BM's realizations of /rn/ reveal some increase in alveolar contact degree as we proceed from /r/ to /n/ and some decrease in amplitude at nasal onset which suggests that the rhotic is being produced. For speaker AR, the cluster /rn/ exhibits perceptually weak /r/ realizations and some lateral linguopalatal contact associated with the rhotic consonant. As for speaker MJ, the rhotic is more or less audible and there is continuous constriction fronting from the postalveolar zone (for /r/) to the central or front alveolar zone (for /n/).

EPG, spectrographic and perceptual evidence for the spontaneous speech data indicates that /r/ drops before /s/ in the sequence per sa "for the" (speakers CA, BM). Though hardly audible, the rhotic stays in per sebre "in order to know" where it may involve the activation of two lateral electrodes at the postalveolar zone (speaker MJ), and in por(c) senglar "wild pig" where /r/ may exhibit lateral constriction fronting from the postalveolar to the centroalveolar area (speaker CA). In other /rC/ combinations, the rhotic also leaves some articulatory trace at the alveolar zone whether audible (in the case of speaker MJ's productions of /rk/ in the word cercar "to look for") or inaudible (in the case of speaker BM's productions of /rm/ in the word germanes "sisters").

5. Discussion

The results reported in this paper show that the path from full identification to elision of syllable-final /s/ and /r/ in Majorcan /sC/ and /rC/ clusters with a voiced C2 is gradient which questions the validity of previous phonetic descriptions. The alveolar fricative may be implemented with a weak frication period resulting from large degrees of oral opening at constriction location or with intermediate approximant realizations involving different degrees of articulatory activity. Some but not all cases of perceived assimilated or elided /s/ may also have some articulatory activity associated with them. Complete elision appears to be possible at the end of the weakening continuum and occurs for the cluster /sl/. Regarding /rC/ clusters, tokens yielding perceived assimilation may show traces of the /r/ gesture. In summary, assimilation and elision are more prone to occur in perception than in production.

Speaker CA proceeds from cluster realizations with different /s/ weakening degrees to productions of /s/ exhibiting full closure and sounding /r/ or /d/. Highly constricted realizations of /s/ for other speakers may also have an /r/-like quality. Therefore, rhotacism may arise from reduced realizations of /s/ and become more regular for some speakers than for others.

Nasals and laterals and, less so, voiced stop consonants may trigger preconsonantal /s/ reduction. Articulatory reduction of preconsonantal /r/ is most prone to occur before (quasi-) homorganic laterals, nasals and /s/.

As argued in the Introduction, it appears that /s, r/ weakening before voiced consonants results from anticipatory intraoral pressure lowering though other factors (anticipatory nasalization, gestural antagonism) may also play an active role.

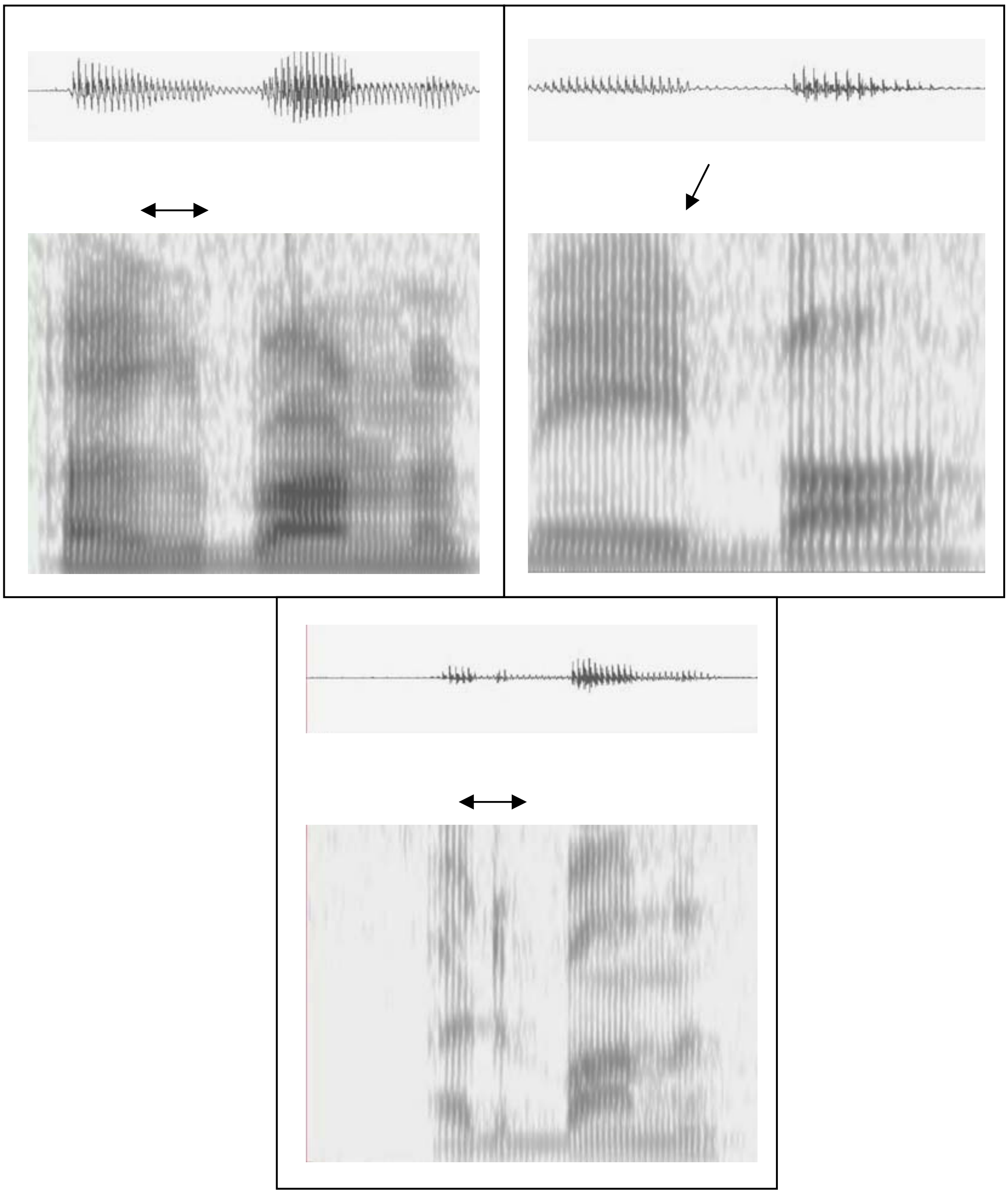

Figure 1. Waveform and spectrographic displays for tokens of the cluster /sb/ showing different /s/ weakening outcomes. Arrows point to /s/ location. (Top left) sequence <u>é**s** **b**ona (tela)</u> «it is a good fabric», speaker AR . (Top right) <u>é**s** **b**o</u> « it is good», speaker ND. (Bottom) <u>é**s** **b**ona (tela)</u> «it is a good fabric», speaker CA.

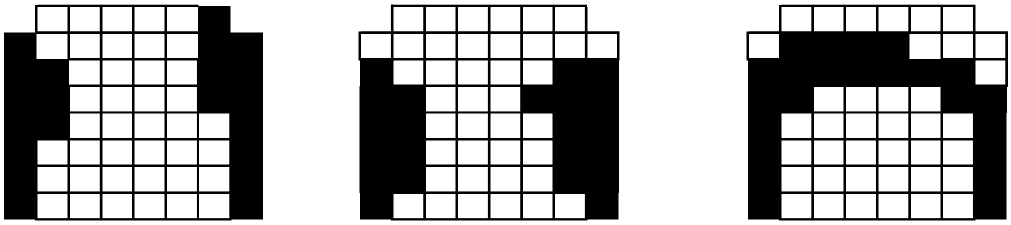

Figure 2. EPG linguopalatal contact configurations for the same tokens of the cluster /sb/ in Figure 1. (Left) sequence é**s b**ona tela «it is a good fabric», speaker AR . (Middle) é**s b**o «it is good», speaker ND. (Right) é**s b**ona tela «it is a good fabric», speaker CA. Electrodes are distributed into horizontal rows and vertical columns. Tongue contact occurs at filled electrodes.

5. References

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