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Serial prosodification and voiced stop geminates in Catalan[*]

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1. Introduction

The main purpose of this paper is to show how the process of voiced stop gemination that applies in Central Catalan finds a straightforward explanation in Harmonic Serialism. In Catalan, root-final clusters involving a labial or a velar voiced stop followed by an alveolar lateral (/bl/, /gl/)[1] surface as geminates ([b.bl], [g.gl]) (Bermúdez-Otero 2000; Bonet & Lloret 1998; Fabra 1912/1982; Mascaró 1987, 2003; Recasens 1991, 1993; Colina 1995; Jiménez 1997; Wheeler 1979, 1980, 2005; Pons-Moll 2004, 2008, 2011). Otherwise, if these clusters precede a vowel belonging to the root, voiced stops spirantize and the cluster is parsed as a complex onset ([.βlV], [.ɣlV]). It is argued that gemination is only triggered when the voiced stop is syllabified in coda position (Mascaró 1987), and in order to fix an ill-formed rising sonority intersyllabic contact (Colina 1995; Jiménez 1997; Pons-Moll 2004, 2008). The insertion of an epenthetic schwa or the presence of a vowel-initial derivational or inflectional suffix do not block gemination, although the presence of these vowels make up the phonological context that could bleed the application of the gemination process, that is, the voiced stop syllabified as the first element of a complex onset. In order to explain these facts, this paper develops a theory of serial syllabification in Harmonic Serialism based on Elfner (2009) and suggests that the binary operation *core syllabification* can create complex degenerate syllables and cannot operate with two adjacent segments if one of them, but not the other, is integrated into a prosodic category higher than the syllable. This means that prosodic categories

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1. Catalan, as many other Romance languages, does not allow tautosyllabic [dl] and [tl] clusters syllabified in onset position.

create opaque domains for syllabification. This assumption, together with serial prosodification, guarantees that vowels outside the root, either epenthetic or inflectional, are not available for syllabification purposes when the root is first syllabified.

This paper is organized as follows. The data is presented in § 2. The theoretical background on which the analysis is based is presented in § 3; this section includes both a brief explanation of Harmonic Serialism and prosodification (§ 3.1), and presents a theory of serial syllabification in Harmonic Serialism with some implications for the prosody-morphology interface (§ 3.2). The Harmonic Serialism analysis is presented in § 4. General conclusions are drawn in § 5.

2.   Data

In Central Catalan, voiced stops in underlying /bl/ and /gl/ clusters undergo a process of gemination provided that those clusters are root-final, as in (1).[2] Note that the examples in (1) surface with a peripheral schwa because tautosyllabic coda clusters with a flat or rising sonority profile are prohibited in Catalan and repaired through schwa epenthesis, with the exception of clusters in which the second consonant is /s/.[3]

(1)   /pɔbl/   ['pɔb.blə]   'town'
       /dobl/   ['dob.blə]   'double'
       /pusibl/   [pu.'sib.blə] 'possible'
       /segl/   ['seg.glə]   'century'

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2.   Mascaró (1987) points out that these alternations are allomorphic in nature: [di.'ab.blə] 'devil' ~ [di.ə.'βɔ.lik] 'devilish'; ['mɔb.blə] 'piece of furniture' ~ [mu.βi.'lja.ɾi] 'furniture'; ['nɔb.blə] 'noble' ~ [nu.βi.'lja.ɾi] 'relative to nobility'; [bu.'lub.blə] 'voluble' ~ [bu.lu.βi.li.'tat] 'volubility'.

3.   Following other scholars, the schwa in (1) is treated as an epenthetic vowel. Its appearance is easily explained as a fixing strategy to an otherwise unsyllabifiable rising-sonority cluster of consonants. It is true that this schwa is also found in words such as ['ɔm+ə] 'man', where positing epenthesis would be unmotivated, but positing a process of epenthesis in (1) is supported by the fact that the unmarked masculine morph in Catalan is a zero morph (['dob.blə] double.masc and [dub.'bl+a] 'to double'). The schwa in (2), however, corresponds to the unmarked feminine morph in Catalan.

The presence of an inflectional suffix such as the feminine morph does not block gemination, because the consonantal cluster is actually root-final.[4]

(2) /regl+ə/ [ˈreg.glə] 'rule'
      /kobl+ə/ [ˈkob.blə] 'stanza'

Elsewhere, that is, when those clusters are not root-final, voiced stops undergo spirantization and they are syllabified as the first element of a complex onset. These root-internal clusters are always followed by a vowel belonging to the root.

(3) /ɛgluɡ+ə/   [ˈɛ.ɣlu.ɣə]   'eclogue'
      /pɾublɛm+ə/   [pɾu.ˈβlɛ.mə]   'problem'
      /ublid+a+ɾ/   [u.βli.ˈða]   'to forget'
      /publi/   [ˈpu.βli]   'Publius'

When the second element of the cluster is a flap (/bɾ/, /ɡɾ/), voiced stops do not geminate, but they spirantize.

(4) /pɔbɾ/ [ˈpɔ.βɾə] 'poor'
      /agɾ/   [ˈa.ɣɾə]   'sour'

Although the aforementioned data correspond to the general pattern described for Central Catalan, /bl/ and /gl/ clusters can also be subject to a process of devoicing and be syllabified in onset position ([ˈpɔ.plə]) or undergo a two-step process of devoicing and gemination ([ˈpɔp.plə]) (Mascaró 1976). Other dialects such as Majorcan Catalan seem to have generalized gemination in those contexts in which the cluster is not root-final (Mascaró p.c.), and Western Catalan completely lacks geminates of that type. It is not the purpose of this paper, however, to address all this dialectal variation.

3.   Theoretical background

3.1   Harmonic Serialism and prosodification

Harmonic Serialism (Prince & Smolensky 1993/2004; Elfner 2009, to appear; Jesney to appear; Kimper 2011; McCarthy 2000, 2007a, b, 2008a, b, 2010a, b, c, 2012, Pruitt 2010) is a non-stratal derivational version of Optimality Theory

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4.   Voiced stop geminates are found in all kinds of derivatives, in both derivational and inflectional contexts: [ˈpub.bl+ik] 'public', [dub.bl+ə.ˈɣ+a] 'to fold', [ə.#rəg.ˈgl+a] 'to fix'.

(Prince & Smolensky 1993/2004). In Harmonic Serialism GEN is restrained by a gradualness condition on candidate generation by which candidates only introduce one single modification with respect to the (latest) input, until convergence on the fully faithful candidate is reached (*i.e.* no further harmonic improvement is possible). An inescapable consequence of gradualness is the need for a GEN → EVAL → GEN … loop, given that output forms are often the result of applying more than one phonological operation. In Harmonic Serialism EVAL imposes the same constraint hierarchy at every step of the derivation. The perdurability of the constraint hierarchy in Harmonic Serialism contrasts with Stratal OT (Kiparsky 2000; Bermúdez-Otero to appear), in which the three recognized levels of phonological evaluation (stem, word and phrase) show a different ranking of the constraint set.

Defining gradualness, that is, exploring what it means to introduce a single phonological operation at a time, is one of the main research interests in Harmonic Serialism.

With regard to syllabification, two different views have been discussed so far in the literature within Harmonic Serialism. If syllabification in tautomorphemic sequences is never contrastive, then faithfulness constraints on syllabification must be excluded from the theory of CON. If gradualness is defined in terms of faithfulness, then syllabification freely applies with other phonological operations (McCarthy 2008b, Elfner to appear, Pruitt 2010). The other view on syllabification departs from an operation-based definition of gradualness. In an operation-based definition of gradualness, not only feature-changing operations correspond to a single step in the derivation, but also structure-building operations, such as syllabification, footing, or parsing a lexical word into a prosodic word. In this perspective, syllabification is also subject to the gradualness requirement on GEN (Jesney to appear, Pater 2012; Elfner 2009). This paper shares the latter view, in which GEN performs prosody-building operations, including syllabification, in a stepwise manner. If prosodification is subject to the gradualness requirement on GEN, then prosody-building operations cannot co-occur with other prosody-building or structure-changing operations.

3.2   A theory of serial syllabification in Harmonic Serialism

This subsection develops a theory of serial syllabification in Harmonic Serialism along the lines of Elfner (2009). In Elfner (2009), a set of three syllable formation operations are proposed: (a) *project syllable*, which creates a syllable (X) from a segment X, where X can be either moraic (X_μ) or not (X); (b) *adjunction*, which takes a segment X and adjoins it to a syllable (Y_μ) or (Y) to the left or the

right, where X can be either moraic (X_μ) or not (X);[5] and (c) *core syllabification* which builds a binary syllable (XY_μ), where Y is a moraic syllable head and X its dependent.[6]

The proposal made in this paper maintains this small set of syllable-building operations, but proposes to modify the formulation of *core syllabification*, as shown in (5).

(5) *Core syllabification* (modified Elfner's 2009 version)
From two segments X and Y, create a binary syllable ($XY_{(\mu)}$), where Y is either a moraic head or a non-moraic dependent of the syllable node, and X is a non-moraic dependent of the syllable node.[7]

This new formulation of *core syllabification* has two advantages. The first one is that *core syllabification* is parallel to the operation *project syllable* because the second parsed segments can be either moraic or not. The second advantage is that it allows the creation of a complex minor syllable if the second segment is a non-moraic segment. This type of configuration, along the lines

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5. An anonymous reviewer interestingly points out that the operation of *adjunction* allows for moraic onsets. Typologically, moraic onsets do not seem to exist (but see Topintzi 2006). The fact that moraic onsets can be generated given the existence of the adjunction of a moraic consonant to the left of an already syllabified moraic nucleus does not necessarily mean that a Harmonic Serialist grammar predicts moraic onsets if there are universal constraints against them. The operation of adjunction is thus not precisely an instance of the duplication problem. Con should be enough to discard them.

6. Elfner (2009) argues that *core syllabification* is necessary in order to discard unattested stress assignment patterns. Her argument is as follows. Imagine a ranking in which Parse-Segment dominates Onset and Onset dominates No-Coda. Without *core syllabification*, an input like /pata/ would be mapped as (pat)(a). Although it is true that a later derivational step would be able to resyllabify the coda as the onset of the following syllable, HS would be able to predict a language where the placement of stress is sensitive to the presence of onset consonants if stress assignment precedes resyllabification. For instance, in a hypothetical language with final stress except in the presence of a heavy syllable, and with the ranking Parse-Segment » Onset » No-Coda, /pata/ might be stressed as (pá)(ta) because stress would be assigned to the intermediate form (pát)(a), and /paa/ might be stressed as (pa)(á). Elfner points out that a stress system like this does not seem to occur. However, further investigations about the duplication problem, which is inherent in a constrained-based model of grammar that incorporates a finite set of operations, are of priority.

7. Notice that in the new formulation of the constraint *core syllabification*, the first segment X is always a non-moraic dependent of the syllable node. This means that *core syllabification* cannot create a ($V_\mu C_\mu$) syllable at once. This configuration emerges derivationally as the result of applying sequentially *project syllable* and then *adjunction*.

of Hayes (1989), can only be interpreted as a minor, degenerate or moraless syllable containing a complex onset, given that only onsets are immediately dominated by the syllable node while codas are always dominated by a mora. These complex minor syllables potentially violate a universal fixed hierarchy of markedness constraints based on a more specific version of the markedness constraint against minor syllables Syllable-Head, *Complex-Syllable-Head. Those constraints refer to the relative harmony of the intrasyllabic sonority profile of complex onsets in minor syllables. The activity of these constraints will be explained in more detail in §3.

The operation of resyllabification defined in (6) will also be crucial in this paper.

(6)   *Resyllabification*
      Take a parsed segment and change its syllabic affiliation parsing it to an already existing syllable, either to its right or to its left.

Resyllabification is a cost-free operation that is not correlated with any faithfulness constraint violation.

Finally, gemination is interpreted as the result of inserting an association line from a previously syllabified root node to a following or previous syllable node. Gemination violates the faithfulness constraint Dep-Link. In §3 the activity of these constraints will be explained in more detail.

3.3   The domain of syllabification

In this paper we assume the standard idea that the input of phonology as an interpretative component of a generative grammar is a set of morphs that stands in a hierarchical morphosyntactic representation, from which linear precedence relations directly follow. Phonological linear immediate precedence relations, or adjacency, come from two different sources. On the one hand, the linear immediate precedence relation between two segments x and y can be established in the lexicon if (a) both x and y are a substring of the same morph; (b) x precedes y in the underlying representation of that morph; and (c) there is no z such that x precedes z and z precedes y. On the other hand, the linear immediate precedence relation between two segments x and y can be inherited from morphosyntax if x is the last segment in the underlying representation of a morph M_1, and y is the first segment in the underlying representation of another morph M_2, and M_1 precedes M_2 after morphosyntax.

In order for core syllabification to apply, the segments x and y must stand in a linear immediate precedence relation. This is implicit in Elfner's (2009) formulation of core syllabification.

However, we also propose to constrain the applicability of core syllabification with respect to another universal condition, formalized in (7), which must be understood as an inherent property or feature of GEN.

(7) GEN-restraint core syllabification in Harmonic Serialism
Let (x, y) stand for a set of segments in a phonological linear immediate precedence relation.
Let $PCat_1$ and $PCat_2$ stand for prosodic categories higher than the syllable, where $PCat_1$ is lower than $PCat_2$.
GEN cannot create a binary syllable (xy) if:
$\exists PCat_1$ s.t. x XOR $y \in PCat_1$ & $\neg\exists PCat_2$ s.t. $x \wedge y \in PCat_2$

As stated in (7), core syllabification is blocked when one of the two segments that stand in a phonological linear immediate precedence relation, but not the other, is dominated by a prosodic category higher than the syllable, and there is no other higher prosodic category that dominates both of them. This means that the presence of a prosodic category higher than the syllable creates an opaque domain for core syllabification.

Following Elfner (2009), the constraints enforcing prosodification are those in (8) and (9).

(8) PARSE-SEGMENT (PRS-SEG): assign one violation mark for every segment that is not associated with a syllable. (Elfner 2009)

(9) PARSE-SYLLABLE (PRS-SYLL)
Assign one violation mark for every syllable that is not associated with a prosodic word.[8] (based on Elfner 2009)

4.   Harmonic Serialism analysis

4.1   Root-internal clusters

This subsection presents a Harmonic Serialism account of those forms that include a root-internal /bl/ cluster that is always followed by a vowel belonging to the root. In these cases, the voiced stop undergoes spirantization and surfaces in onset position along with the following lateral (/publi/ → ['pu.βli]).

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8.   An orthodox definition of PARSE-SYLLABLE should refer to metrical feet. It is assumed here that syllables are directly parsed into prosodic words for ease of exposition. For discussions on foot parsing in Harmonic Serialism, see McCarthy (2008b) and Pruitt (2010).

The first step of the Harmonic Serialism derivation appears in tableau (12), where the relevant syllable-building operations are included. At this step of the derivation, candidates (a) and (h) are the winners, which are the ones that show the application of core syllabification projecting a mora. These are the candidates that minimally violate Parse-Segment, and violate neither *σ/O,R,[9] which assigns one violation mark for every moraic obstruent or sonorant as a syllable head, nor *Complex-Syllable-Head, which is violated by candidate (g). The cover constraint *Complex-Syllable-Head, which will be split into two more specific constraints in the next subsections, is a markedness constraint that stands in a stringency relation with the less stringent constraint Syllable-Head. Both constraints are defined in (10) and (11) below.

(10)   Syllable-Head (Syll-Head)
        Assign one violation mark for every syllable that does not dominate at least one mora. (Elfner 2009)

(11)   *Complex-Syllable-Head (*Complex-Syll-Head)
        Assign one violation mark for every complex syllable that does not dominate at least one mora.

All the other candidates are harmonically bounded by the winner. Ties are common in Harmonic Serialism when the same operation is applicable at different *loci*. For expository reasons, candidate (a) is taken as the input to the next step of the derivation, the one with left-to-right parsing. Taking candidate (h) would yield the same result. Parentheses mark syllable boundaries.

(12)   Step 1

/publi/	*σ/O,R	Prs-Seg	Syll-Head	*Comp-Syll-Head	*Operations*
a. →(pu$_\mu$)bli		3			*core σ with μ*
b. (p$_\mu$)ubli	W$_1$	W$_4$			*σ with μ*
c. p(u$_\mu$)bli		W$_4$			*σ with μ*
d. pu(b$_\mu$)li	W$_1$	W$_4$			*σ with μ*
e. pub(1$_\mu$)i	W$_1$	W$_4$			*σ with μ*

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9.   Elfner (2009) proposes a universal fixed hierarchy of markedness constraints, namely *σ/O » *σ/R » *σ/V, that explain the cross-linguistic preference for high sonority segments to head syllables.

/publi/	*σ/O,R	Prs-Seg	Syll-Head	*Comp-Syll-Head	Operations
f. publ(i$_\mu$)		W$_4$			σ with μ
g. pu(bl)i		3	W$_1$	W$_1$	core σ without μ
h. →pub(li$_\mu$)		3			core σ with μ
i. (p)ubli		W$_4$	W$_1$		σ without μ
j. publi		W$_5$			Ø

At the second step of the derivation (tableau 13), applying again core syllabification minimally violates Parse-Segment and does not violate any other constraint. The most harmonic candidate, candidate (a), harmonically bounds all the other candidates.

(13)   Step 2

/publi/	*σ/O,R	Prs-Seg	Syll-Head	*Comp-Syll-Head	Operations
a. →(pu$_\mu$)b(li$_\mu$)		1			core σ with μ
b. (pu$_\mu$b$_\mu$)li		W$_2$			adjunction
c. (pu$_\mu$)(b)li		W$_2$	W$_1$		σ without μ
d. (pu$_\mu$)(bl)i		1	W$_1$	W$_1$	core σ without μ
e. (pu$_\mu$)(bl$_\mu$)i	W$_1$	1			core σ with μ
f. (pu$_\mu$)(b$_\mu$)li	W$_1$	W$_2$			σ with μ
g. (pu$_\mu$)bli		W$_3$			Ø

At the next step (tableau 14), the input contains only one unparsed segment. The winning candidate, candidate (a), is the one in which the unparsed voiced stop is parsed as the first element of a complex onset to the second syllable. Applying onset adjunction is more harmonic than applying coda adjunction, as candidate (b) shows, because No-Coda dominates *Complex-Onset. *Complex-Onset is dominated by Syllable-Head, as the comparison with candidate (c) illustrates. The fully faithful candidate, candidate (d), is also ruled out because it fatally violates Parse-Segment, which dominates *Complex-Onset. The selected candidate also violates a low-ranked markedness constraint against postvocalic heterosyllabic voiced stops. We use an *ad hoc* constraint *V.b… for ease of exposition. The satisfaction of this markedness constraint will trigger spirantization.

(14)   Step 3

/(pu$_\mu$)b(li$_\mu$)/	*σ/O,R	PRS-SEG	SYLL-HEAD	NO-CODA	*COMP-ONS	*V.b...	Operations
a. →(pu$_\mu$)(bli$_\mu$)					1	1	adjunction
b. (pu$_\mu$b$_\mu$)(li$_\mu$)				W₁	L	L	adjunction
c. (pu$_\mu$)(b)(li$_\mu$)			W₁		L	1	σ without μ
d. (pu$_\mu$)b(li$_\mu$)		W₁			L	L	Ø
e. (pu$_\mu$)(b$_\mu$)(li$_\mu$)	W₁				L	1	σ with μ

At the fourth step (tableau 15), spirantization applies in order to remove the violation of *V.b.…. This constraint dominates the faithfulness constraint IDENT [continuant], which assigns one violation mark for every corresponding segments in the input and the output with a different specification of the feature [continuant]. NO-CODA also dominates IDENT [continuant].

(15)   Step 4

/(pu$_\mu$)(bli$_\mu$)/	NO-CODA	*COMP-ONS	*V.b...	ID [cont]	Operations
a. →(pu$_\mu$)(βli$_\mu$)		1		1	spirantization
b. (pu$_\mu$)(bli$_\mu$)		1	W₁	L	Ø
c. (pu$_\mu$b$_\mu$)(li$_\mu$)	W₁	L		L	resyllabification

The derivation converges at the next step of the derivation (tableau 16), where no harmonic improvement is achievable.

(16)   Step 5: convergence

/(pu$_\mu$)(βli$_\mu$)/	NO-CODA	*COMP-ONS	*V.b...	ID [cont]	Operations
a. →(pu$_\mu$)(βli$_\mu$)		1			Ø
b. (pu$_\mu$)(bli$_\mu$)		1	W₁	W₁	fortition
c. (pu$_\mu$β$_\mu$)(li$_\mu$)	W₁	L			resyllabification

To sum up, when the cluster /bl/ appears root-internally and followed by a vowel belonging to the root, gemination is blocked because the voiced stop is syllabified as the first element of a complex onset at step 3 of the derivation. The process of

gemination, as it will be made clear in the next subsection, can only apply as long as the voiced stop is parsed in coda position.

4.2   Root-final /bl/ clusters

The analysis of the cases in which a /bl/ cluster appears root-finally is given in this subsection. The first step of the derivation, in which a core syllable is created, is omitted here. The difference between an input containing a /bl/ cluster root-finally and an input containing the same cluster root-internally arises at the second step of the derivation (tableau 17). Given the absence of a vowel in an input such as /pɔbl/, core syllabification, as candidate (d) illustrates, does not represent a harmonically-improving step because *σ/O,R dominates Parse-Segment. The winning candidate is then candidate (a), the one that parses the voiced stop in coda position to the previously existing syllable. However, there is the possibility of building a syllable that parses the /bl/ cluster together, as candidate (c) shows. This operation would completely satisfy Parse-Segment. However, this potential candidate is ruled out because it fatally violates a markedness constraint that, for clarity of exposition, is written here as *(bl)-Syllable-Head, which assigns one violation mark for every complex minor syllable with a (b/ɡl) complex onset. This paper argues for the existence of a universal fixed hierarchy of sonority-driven markedness constraints on possible complex onsets in minor syllables that stand in a stringency relation with Syllable-Head. Following Pons-Moll (2008, 2011), we assume that laterals are less sonorous than flaps in Romance. That universal constraint hierarchy is based on the Sonority Dispersion Principle (Clements 1990), according to which the more sonority distance between the segments in a complex onset, the better. Given that flaps are more sonorous than laterals, a complex minor syllable like (b/ɡɾ) will always be more harmonic than a complex minor syllable like (b/ɡl). This is expressed by ranking *(b/ɡl)-Syllable-Head over *(b/ɡɾ)-Syllable-Head. As can be seen in the following tableau, *(bl)-Syllable-Head also outranks Parse-Segment.

(17)   Step 2

/(pɔ$_\mu$)bl/	*σ/O,R	*(b1)-SYLL-HEAD	PRS-SEG	SYLL-HEAD	NO-CODA	*V.b...	Operations
a. →(pɔ$_\mu$b$_\mu$)l			1		1		*adjunction*
b. (pɔ$_\mu$)bl			W$_2$		L		Ø
c. (pɔ$_\mu$)(bl)		W$_1$	L		L	W$_1$	*core σ without μ*

d. $(pɔ_μ)(bl_μ)$	W_1		L		L	W_1	*core σ with μ*
e. $(pɔ_μ)(b_μ)l$	W_1		1		L	W_1	*σ with μ*
f. $(pɔ_μ)(b)l$			1	W_1	L	W_1	*σ without μ*

At the third step of the derivation (tableau 18), the unsyllabified lateral is parsed into a single minor syllable, as candidate (a) shows. This is the most harmonic candidate at this stage of the derivation because all the segments have been parsed into syllables. Parse-Segment thus dominates Syllable-Head. The winning candidate violates a constraint not presented yet, namely Syllable-Contact (Syll-Cont) (see, among others, Gouskova 2004), which prohibits heterosyllabic clusters with a flat or rising sonority profile. Applying again coda adjunction to (pɔb) would result in a complex coda with an intrasyllabic rising sonority profile, *(pɔbl), as candidate (c) illustrates, which is banned by Sonority-Sequencing (Baertsch 2002). The markedness constraint Sonority-Sequencing (Son-Seq) militates against complex codas in which the first element is less sonorous than the second one. The last candidate is also ruled out because it violates the higher-ranked constraint *σ/O,R. The next tableau demonstrates that both Sonority-Sequencing and Parse-Segment dominate Syllable-Contact and Syllable-Head, which is dominated by *σ/O,R.

(18) Step 3

/$(pɔ_μb_μ)l$/	*σ/O,R	Son-Seq	Parse-Seg	Syll-Cont	Syll-Head	No-Coda	*Operations*
a. →$(pɔ_μb_μ)(l)$				1	1	1	*σ without μ*
b. $(pɔ_μb_μ)l$			W_1	L	L	1	Ø
c. $(pɔ_μb_μl)$		W_1		L	L	1	*adjunction*
d. $(pɔ_μb_μ)(l_μ)$	W_1			1	L	1	*σ with μ*

At the next step (tableau 19), the winning candidate is the one that removes the violation of Syllable-Head by epenthesizing a schwa, which is correlated with a Dep-V violation. Gemination, on the one hand, and resyllabification, on the other hand, are not harmonically improving operations at this stage of the derivation because of the high ranking of *(bl)-Syllable-Head, which rules out candidate (c). The high ranking of a faithfulness constraint against mora deletion, Max-μ (Lin 1997), which is violated by candidate (d), is also included in tableau (19). The constraint *(bl)-Syllable-Head dominates Syllable-Contact.

(19)   Step 4

/(pɔ$_\mu$b$_\mu$)(l)/	MAX-μ	*(bl)-SYLL-HEAD	SYLL-CONT	SYLL-HEAD	DEP-V	Operations
a. →(pɔ$_\mu$b$_\mu$)(lə$_\mu$)			1		1	epenthesis
b. (pɔ$_\mu$b$_\mu$)(l)			1	W$_1$	L	Ø
c. (pɔ$_\mu$b$_\mu$)(bl)		W$_1$	L	W$_1$	L	gemination
d. (pɔ$_\mu$)(bl)	W$_1$	W$_1$	L	W$_1$	L	resyllabification

At the fifth step of the derivation (tableau 20), gemination is able to apply in order to avoid a rising sonority profile between the two heterorganic consonants. Resyllabification is blocked by the activity of MAX-μ. The winning candidate, candidate (a), thus violates the low-ranked markedness constraint DEP-LINK, which assigns one violation mark for every root node multiply linked to higher prosodic tiers only in the output.

(20)   Step 5

/(pɔ$_\mu$b$_\mu$)(lə$_\mu$)/	MAX-μ	SYLL-CONT	NO-CODA	*COMP-ONS	DEP-LINK	Operations
a. →(pɔ$_\mu$b$_\mu$)(blə$_\mu$)			1	1	1	gemination
b. (pɔ$_\mu$b$_\mu$)(lə$_\mu$)		W$_1$	1	L	L	Ø
c. (pɔ$_\mu$)(blə$_\mu$)	W$_1$		L	1	L	resyllabification

Convergence is met at the next step of the derivation, omitted here. The analysis proposed so far has demonstrated that the opaque interaction between gemination and schwa epenthesis, which stand in a counterbleeding relation, is straightforwardly captured by Harmonic Serialism, where processes are applied in a step-wise manner under the same constraint hierarchy.

4.3   Root-final /bɾ/ clusters

At this point of the discussion, those inputs containing a /bɾ/ cluster root-finally can be compared with those ones containing a /bl/ cluster. The crucial difference between an input like /pɔbl/ and an input like /pɔbɾ/ is that in the former case, as has been demonstrated, the creation of a complex minor syllable is not possible to build at the second step of the derivation (tableau 17) because of the ranking *(bl)-SYLLABLE-HEAD » PARSE-SEGMENT. However, if PARSE-SEGMENT dominates *(bɾ)-SYLLABLE-HEAD, then a binary complex minor syllable with an

empty nucleus emerges as the most harmonic candidate at the second step of the derivation for inputs with a root-final /bɾ/ cluster. Then, if the voiced stop is not syllabified in coda position, but in onset position, there is no chance for gemination to apply later in the derivation, because SYLLABLE-CONTACT is already satisfied. The second step for /pɔbɾ/ is illustrated below.

(21)   Step 2

/(pɔ_μ)bɾ/	PRS SEG	*(bɾ)-SYLL-HEAD	SYLL-HEAD	NO-CODA	*COMP-ONS	*V.b...	Operations
a. →(pɔ_μ)(bɾ)		2	1		1	1	core σ without μ
b. (pɔ_μ)bɾ	W₂	L	L		L	L	Ø
c. (pɔ_μb_μ)ɾ	W₁	L	L	W₁	L	L	adjunction

At step 3 (tableau 22), an epenthetic schwa is inserted because this is the most harmonic operation that compels the satisfaction of *(bɾ)-SYLLABLE-HEAD, given the ranking *(bɾ)-SYLLABLE-HEAD » DEP-V.

(22)   Step 3

/(pɔ_μ)(b)/	*(bɾ)-SYLL-HEAD	SYLL-HEAD	DEP-V	*COMP-ONS	*V.b...	Operations
a. →(pɔ_μ)(bɾə_μ)			1	1	1	epenthesis
b. (pɔ_μb_μ)(ɾ)		W₁	L	L	L	resyllabification
c. (pɔ_μ)(bɾ)	W₁	W₁		1	1	Ø

Later on (tableau 23), spirantization applies in order to satisfy *V.b…, the constraint against postvocalic heterosyllabic voiced stops. The derivation converges at the next step of the derivation, not shown here.

(23)   Step 4

/(pɔ_μ)(bɾə_μ)/	NO-CODA	*COMP-ONS	*V.b...	ID [cont]	Operations
a. →(pɔ_μ)(βɾə_μ)		1		1	spirantization
b. (pɔ_μ)(bɾə_μ)		1	W₁	L	Ø
c. (pɔ_μb_μ)(ɾə_μ)	W₁	L		1	resyllabification

In this subsection it has been shown that the ranking between the constraints *(bl)-Syllable-Head and *(bɾ)-Syllable-Head with respect to Parse-Segment, namely *(bl)-Syllable-Head » Parse-Segment » *(bɾ)-Syllable-Head, explains the asymmetry between those inputs containing a root-final cluster /bl/ and those containing /bɾ/. The fact that *(bl)-Syllable-Head is higher-ranked forces the voiced stop to be syllabified in coda position, at the expense of violating Parse-Segment, which triggers gemination later on in the derivation in order to fix an intersyllabic rising sonority contact.

4.4 Voiced stop plus lateral root-final clusters followed by overt inflectional suffixes

As stated in §2, voiced stop gemination also stands in a counterbleeding relation with morphological affixation. The presence of a vowel-initial derivational or inflectional suffix does not block gemination, although the presence of vowel-initial suffixes introduce the phonological context that could bleed the application of gemination by allowing core syllabification to apply to those sequences.

As introduced in §3.3, in this paper it is proposed that prosodic categories higher than the syllable create opaque domains for syllabification. This fact explains why an input like /regl+ə/, consisting of a root followed by the inflectional feminine morph, as opposed to /publi/, where the last vowel belongs to the underlying lexical form of the root, escapes spirantization and undergoes gemination if first the root is parsed into its own prosodic word. The vowel belonging to the feminine morph cannot be integrated into a syllable together with the last consonant of the root at the steps of the derivation in which syllabification applies. This is so because there is a prosodic word dominating the root but not the affix, which creates an opaque domain for syllabification. This situation emerges if a prosody-morphology interface constraint requiring the right edge of the root to be aligned with some prosodic word, Align-Right (Root, Prosodic Word) (Al-R ($\sqrt{}$, ω)) dominates Parse-Segment. If the alignment constraint is first satisfied, the root in /regl+ə/ is syllabified the same way /pɔbl/ is, where the voiced stop is parsed as a syllable coda and the lateral forms a single minor syllable. The vowel belonging to the suffix is parsed into its own syllable, yielding the following intermediate representation: $(re_\mu g_\mu)(l)+(ə_\mu)$. At that point, a prosodic word dominating all the syllables is the most harmonic candidate given the ranking Parse-Syllable » Syllable-Head, as tableau (24) illustrates. The winning candidate is thus candidate (a), with a recursive prosodic word.[10] Square brackets mark prosodic word

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10.　We could assume that the last syllable of the string is adjoined to the already existing prosodic word, instead of being adjoined to a recursive prosodic word that dominates the inner

boundaries and the symbol '+' indicates that there is a prosodic word boundary separating the root and the affix. This prosodic word boundary creates an opaque domain that prevents core syllabification to operate with the last consonant of the root and the vocalic suffix.

(24)

/[(re$_\mu$g$_\mu$)(l)]+(ə$_\mu$)/	Prs-Syll	Syll-Cont	Syll-Head	Dep-V	Operations
a. →[(re$_\mu$g$_\mu$)(l)] (ə$_\mu$)		1	1		ω building
b. [(re$_\mu$g$_\mu$)(lə$_\mu$)]+(ə$_\mu$)	W$_1$	1	L	W$_1$	epenthesis
c. [(re$_\mu$g$_\mu$)(l)]+(ə$_\mu$)	W$_1$	1	1		Ø

At this point of the derivation, syllabification is sensitive to the whole string of segments dominated by the prosodic word. Syllable-Head must thus be satisfied. Among the alternatives, conflating the single minor syllable together with the onsetless syllable into one syllable is the most harmonic one, given that this operation is not correlated with any violation of a faithfulness constraint, as opposed to inserting an epenthetic vowel, correlated with a Dep-V violation. This is demonstrated in the tableau (25).
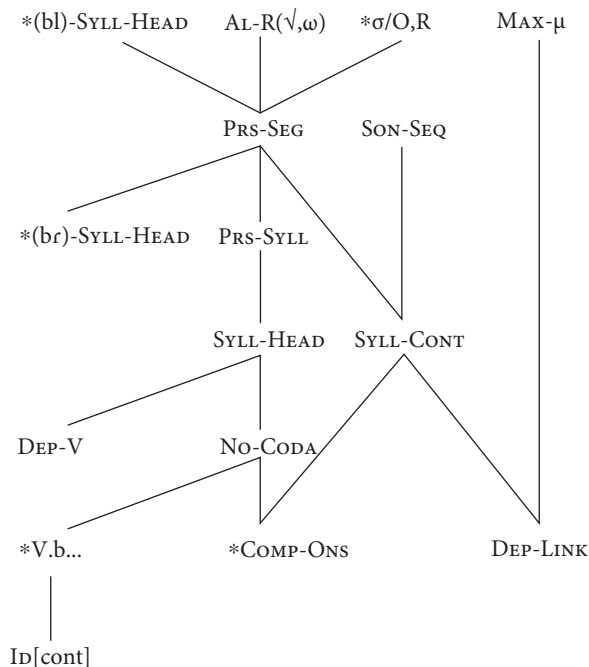
(25)

/[[(re$_\mu$g$_\mu$)(l)](ə$_\mu$)/	Syll-Cont	Syll-Head	Dep-V	Operations
a. →[[(re$_\mu$g$_\mu$)(lə$_\mu$)]]	1			ω building
b. [[(re$_\mu$g$_\mu$)(lə$_\mu$)](ə$_\mu$)]	1		W$_1$	epenthesis
c. [[(re$_\mu$g$_\mu$)(l)](ə$_\mu$)]	1	W$_1$		Ø

At that point of the derivation, the input /[[(re$_\mu$g$_\mu$)(lə$_\mu$)]]/ is parallel to the input /(pɔ$_\mu$b$_\mu$)(lə$_\mu$)/ in tableau (20). Gemination applies at the next step to satisfy Syllable-Contact.

The final ranking of the whole set of constraints presented so far appears in (26) as a Hasse diagram.

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prosodic word. But saying this would force us to assume that Align-Right(Root, Prosodic Word) is only violated in the absence of input syllables, in order to make this constraint active before syllabification, and inactive after syllabification, which seems a stipulative assumption.

(26)

*(bl)-Syll-Head   Al-R(√,ω)   *σ/O,R   Max-μ

                        Prs-Seg   Son-Seq

*(bɾ)-Syll-Head   Prs-Syll

                        Syll-Head   Syll-Cont

Dep-V   No-Coda

*V.b...   *Comp-Ons   Dep-Link

Id[cont]

5.   Conclusions

This paper has presented a Harmonic Serialism analysis of voiced stop gemination in Catalan and has shown how this serial model without strata is able to derive some opaque forms which show counterbleeding interactions between voiced stop gemination, schwa epenthesis and suffixation.

The analysis rescues two essential ideas from previous literature on voiced stop gemination in Catalan: gemination only applies when voiced stops are parsed in coda position (Mascaró 1987) as a strategy to avoid a rising syllable contact (Bermúdez-Otero 2000; Colina 1995; Jiménez 1997; Pons-Moll 2004, 2008, 2011). The data analyzed in this paper require a crucial ordering between different phonological operations: syllabification, epenthesis and gemination. The interaction between those operations can be straightforwardly accounted for in Harmonic Serialism if prosody-building operations count as a single step (Elfner 2009). Two different proposals about syllabification have been made that explain the asymmetries between voiced stop plus lateral root-final clusters, with or without inflectional suffixes, on the one hand, and voiced stop plus tap clusters, on the other hand. First, a theory of serial syllabification in

Harmonic Serialism based on Elfner (2009) has been developed. We have proposed that the binary operation *core syllabification* can create complex minor syllables and cannot operate with two adjacent segments if one of these segments, but not the other, is integrated into a prosodic category higher than the syllable. This situation allows for positing a universal fixed hierarchy of markedness constraints disfavoring those complex onset configurations based on the Sonority Dispersion Principle (Clements 1990), according to which a complex minor syllable like (bl) is more marked than a complex minor syllable like (bɾ), given that taps behave as more sonorous than laterals in Romance (Pons-Moll 2008, 2011). The constraint ranking *(bl)-Syllable-Head » Parse-Segment » *(bɾ)-Syllable-Head explains the difference between ['pɔb.blə], with gemination, and ['pɔ.βɾə], with spirantization. Second, the asymmetry between /publi/ → ['pu.βli], with spirantization, and /regl+ə/ → ['reg.glə], with gemination, is explained resorting to the idea that the presence of a prosodic word boundary creates an opaque domain for syllabification operations. This restriction on Gen about syllable formation operations together with the ranking Align-Right(Root, ProsodicWord) » Parse-Segment ensures that words with voiced stop plus lateral root-final clusters with overt suffixes (*i.e.* /regl+ə/) behave like words without overt morphs (*i.e.* /pɔbl/), which show gemination, instead of behaving like words with a final vowel belonging to the root (*i.e.* /publi/), which undergo spirantization.

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