Sonority Scales and the Syllable Template

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0. Introduction

Steriade (1982) proposes the elimination of the syllable template, a device assumed by many phonologists in order to capture the notion of "possible syllable" for a particular language. She argues that the information contained within the template is better conveyed through the use of syllable-building rules which are subject to language-particular well-formedness constraints. The primary constraint is a required minimal difference in sonority between members of a tautosyllabic cluster, the relative sonority being determined by a parameterized sonority hierarchy. Some advantages of this approach are that it allows separation of non-predictable from predictable information (e.g., that all languages have a rule σ --> (O) R), and also that it allows one to capture mirror-image properties of onset and coda structure where this exists.

In this paper I show that an extension of Steriade's model to Spanish reveals some problems for the model. First, it is not possible to devise a sonority hierarchy that allows just the actually occurring tautosyllabic clusters in Spanish. Second, the sonority hierarchy, which deals with a type of surface phonotactics, cannot be extended to account for constraints on nucleus structure as well as tautosyllabic clusters.

Selkirk (1984) deals with these problems in Spanish using a numerical sonority scale and the syllable template. Her satisfactory account of Spanish syllable structure raises the question as to whether the syllable template is indeed necessary to account for the phonotactics of a language. I will show that Steriade's basic insight that syllable templates are unnecessary is a correct one, but that her proposal will account for a larger body of data if it is modified in certain ways proposed here.

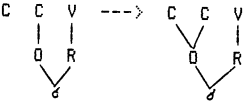
The organization of this paper is as follows. In section 1 I present an outline of Steriade's syllabification model. Next, using Harris' (1983) analysis of Spanish syllable structure I extend Steriade's framework to Spanish and discuss the problems encountered. In section 3 I present Selkirk's analysis of Spanish syllable structure. Finally, I propose an analysis of Spanish syllable structure which incorporates basic insights of both Steriade's and Selkirk's proposals.

1. Steriade's Proposal

Syllabification within Steriade's framework results from the application of a set of core syllable-building rules such as shown in (1)-(3). Rule (1) is universal and captures the observation that CV syllables are maximally unmarked. The adjunction rules (2) and (3) create branching onsets and rhymes respectively.

(1) (C) V ---> (C) V (Universal)

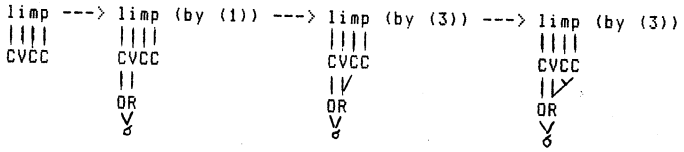
(2) C C V ---> C C V (Onset rule)



(3) V C ---> V C (Coda rule)

An example of the syllabification of the English word *limp* is given in (4).

(4) limp ---> limp (by (1)) ---> limp (by (3)) ---> limp (by (3))



Any stray C's left after core syllable rule application are either adjoined by language-specific stray adjunction rules or lost via the Stray Erasure Convention, shown in (5), which erases stray segments (Steriade 1982:89).

(5) Stray Erasure Convention:

> Erase segments and skeleton slots unless attached to higher levels of structure (i.e., a position within the syllable or within a morphological template).

The application of the core syllable rules is subject to language-specific constraints on the relative sonority of adjacent tautosyllabic segments. Steriade proposes a parameterized feature-based sonority scale which may vary across languages by the inclusion of the feature(s) needed to delineate the segments of a particular language in question into sonority groups. In addition, each language establishes a Minimal Sonority Distance (MSD) requirement which represents the minimal number of intervals on the scale which must separate tautosyllabic clusters.

Classical Latin, for example, allowed only stop + liquid clusters (except tl, dl) in core onsets. The scale proposed by Steriade in (6) shows that Latin chose as its parameter the feature [coronal]. The MSD requirement for Latin is 6.

(6) Classical Latin Sonority Scale:

[-son, -cont, -cor]: p,k,b,g	Core Onsets Allowed:	
[-son, -cont, +cor]: t,d	stop + liquid	
[-son, +cont, -cor]: f		
[-son, +cont, +cor]: s		
[+son, -cont, +nas, -cor]: m		
[+son, -cont, +nas, +cor]: n	MSD = 6	
[+son, +cont, -nas, +lat]: l		
[+son, +cont, -nas, -lat]: r		

Attic Greek, on the other hand, allowed different core onsets and thus had a different scale and a different MSD requirement as shown in (7).

(7) Attic Greek Sonority Scale:

[-son, -cont, -voice]: p,t,k	Core Onsets Allowed:
[-son, -cont, +voice]: b,d,g	vl. stop + sonorant
[-son, +cont, -voice]: s	vd. stop + liquid
[-son, +cont, +voice]: z	
[+son, -cont, +nas]: n,m	
[+son, +cont, -nas, +lat]: l	MSD = 4
[+son, +cont, -nas, -lat]: r	

Onset or coda length is determined primarily by conditions on relative sonority of tautosyllabic clusters. For example, that Greek does not have core onsets of three segments is due to the fact that there do not exist three segments separated by four intervals each under the conditions provided in (7).

To summarize, Steriade proposes a syllabification model consisting of a set of syllable-building rules which are subject to language-particular well-formedness constraints including a parameterized sonority hierarchy and a required minimal difference in sonority.

2. Spanish Syllable Structure

Onsets in Spanish are optional and may consist of one or two segments. A one-place onset may be filled by any consonantal segment. Two-place onsets may be one of the following obstruent plus liquid clusters (Harris 1983:14).

(8) Possible Onset Clusters: Examples:

pr/pl	tr	kr/kl	preso plano	tres	crema claro
br/bl	dr	gr/gl	brazo blando	drama	gris globo
fr/fl		?xr/?xl	fresco flan		(Jruschef)

Given the similarity of Spanish onsets to those of Classical Latin it appears that Spanish chose the same parameter as Latin for its sonority scale, namely coronality. However, since Spanish /t,d/ are dental, hence [-cor], the additional feature [anterior] is necessary to obtain the needed classes, as shown in (9).

(9) Spanish Sonority Scale:

[-son, -cont, -cor, -ant]: p,k,b,g
[-son, -cont, +cor, +ant]: t,d
[-son, -cont, +cor]: č
[-son, +cont, -cor]: f,x
[-son, +cont, +cor]: s
[+son, -cont, +nas, -cor]: m
[+son, -cont, +nas, +cor]: n,ñ
[+son, +cont, -nas, +lat]: l
[+son, +cont, -nas, -lat]: r

Now we need to determine the appropriate MSD requirement. A MSD of 7 applied to the scale in (9) will allow only the permissible stop + liquid clusters. However it will disallow fricative + liquid clusters, some of which occur in Spanish, because they have an MSD less than 7. One might propose that fricative + liquid clusters are not tautosyllabic. The following evidence suggests that at least f + liquid clusters are tautosyllabic. Nonverb forms can take antepenultimate stress if the penult is open, i.e., non-branching, as shown in (10a). The forms in (10b), with branching rhymes, are judged by native speakers as being acceptable if stress is on the penult. On the other hand the forms in (10c), in which the penultimate vowel is followed by an obstruent + liquid cluster, have antepenultimate stress. This confirms that these clusters are onset clusters since if the obstruents were in the codas, one would expect to find penultimate stress.

(10) a. telé.fo.no

b. (tele.fós.no) vs. *(telé.fos.no)
(tele.bói̯.na) *(telé.boi̯.na)

c. múl.ti.ple
i.dó.la.tra
(po.lí.no.fra)

(N.B. Parentheses indicate hypothetical forms)

Any attempt to lower the MSD requirement for Spanish in order to allow for the permissible fricative + liquid clusters will produce further disallowed clusters. An MSD of 5, for example, would allow fricative + liquid clusters but also stop + nasal clusters among others. Similar problems occur with other scales which might be constructed, i.e., they cannot account for just the actually occurring onset clusters. Thus the first problem encountered in extending Steriade's model to Spanish is one of empirical inadequacy.

Turning to the rhyme data, we see in (11) the possible rhyme types in Spanish (Harris 1983:14). According to Harris, a rhyme may consist of no more than three segments.

(11) Possible Rhyme Types:

a.	b.	c.	d.
V	Vs	GV	GVs
VG	VGs	GVG	
VL	VLs	GVL	
VN	VNs	GVN	
VO	VOs	GVO	

Examples:

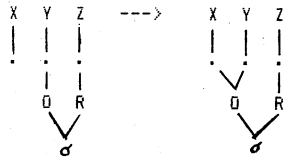
a.	b.	c.	d.
pa.ta	pas.ta	nue.vo	fies.ta
au.tor	claus.tro	buey	
sal.ta	pers.pi.caz	fuer.te	
com.pra	mons.truo	Juan	
seg.men.to	abs.trac.to	diag.no.sis	

One might be inclined to eliminate the rhyme types in (11c) by saying that glides occur within the onset. Harris argues that these glides are in fact part of the rhyme for the same reason that f + liquid clusters are part of the onset. Hypothetical words such as (12) are acceptable when stress is on the penult, whereas the same words with stress on the antepenult, are ill-formed. This suggests that the words in (12) contain branching rhymes much like the words in (10b).

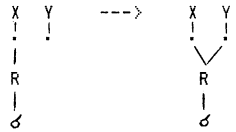
(12) (tele.fió.no) vs. *(telé.fio.no)
(tele.fué.no) *(telé.fue.no)

Several issues arise concerning syllabification rules and the rhyme. The first is how to account for the sequences in (11c) and (11d), since the coda rule (3) adjoins only C's. Clearly, the interpretation of a segment as a glide or vowel is determined by its position within a syllable and its relative sonority with respect to adjacent vowels. One must be able to derive glide or vowel status; it is not primary. Such facts have led others to posit a dot tier rather than a CV tier (cf. Lowenstamm and Kaye 1982, Levin 1983, and Prince 1984). The basic motivation for the dot tier is that the interpretation of elements on this tier as C or V is derivable from higher level prosodic structure. The facts from Spanish argue that the dot tier is required. Incorporating the dot tier into the onset and coda rules discussed in section 1 gives the revised rules shown below:

(2') Onset Rule:



(3') Coda rule:



Thus, Steriade's proposal must be revised to incorporate the dot tier as the organizing tier rather than the CV tier. In principle the onset rule (2') and the coda rule (3') apply as intended by Steriade. However we have already seen, at least for onset clusters in Spanish, that the formulation of an appropriate sonority scale is not possible. Let us now turn to the problem of accounting for consonant clusters within the rhyme.

The only syllable-final clusters allowed consist of a consonant followed by s. A glance at the scale in (9) shows that it is impossible to account for these and only these permissible clusters with this scale or, for that matter, any other scale. While onset clusters are determined by sonority and the problem is devising a scale, the lack of an appropriate scale for coda clusters stems from the fact that sonority is not an issue. Rather, it is simply a fact of Spanish rhymes that an s may be adjoined if the rhyme consists of no more than two segments.

A possible solution within Steriade's model would be to assume that these clusters are heterosyllabic, thus requiring a Stray Adjunction rule to adjoin s to the preceding syllable. However Harris points out that while s can be extrametrical, it is so only when it occurs outside the derivational stem. When part of the derivational stem, s 'counts' with respect to rhyme length. Thus while there is need for a stray adjunction rule to adjoin stray s's which are outside the derivational stem, we also need a language-particular rule which simply adjoins s to a rhyme. This rule is not a stray adjunction rule nor is it the revised rhyme building rule (3'). It is another core syllable-building rule which only adjoins s.

The last issue which remains is that of rhyme length. Within Steriade's model this is accounted for by constraints on sonority (e.g., via the MSD requirement). However, we have seen that sonority is not a constraint on Spanish rhyme clusters. Therefore some other means must be found to prevent incorrect adjunction of s, e.g., to one of the sequences in (11c). A constraint in terms of number of segments cannot be placed on the s-adjunction rule since the syllable-building rules do not 'know' the number of segments which they have adjoined--nor should they given the assumptions of the model. Similarly, a constraint in

terms of V's and C's is also impossible since with the dot tier model since this information is no longer available.

The extension of Steriade's model to Spanish syllable structure thus reveals a number of problems for her model. The first is one of empirical inadequacy; it was not possible to formulate a sonority hierarchy for either the onset or coda clusters separately let alone for both together. In addition, other problems arise which stem from the fact that certain facts of Spanish syllable structure do not involve sonority, namely that s may be adjoined to any adjacent tautosyllabic consonant regardless of sonority.

The fact that glides may be an initial member of the rhyme posed a problem for the syllable rules as they were formulated. To remedy this it was proposed that the CV tier be replaced by a dot tier. However this solution indirectly prevents solution of another problem, namely, that of constraining the s-adjunction rule to apply only when there are two or less segments in the rhyme.

These problems point to two major difficulties with Steriade's model. The first is that a feature-based sonority scale is too limited. The second is that it is biased towards sonority constraints. However, it is a fact that there are certain phonotactics which are independent of sonority. Within Steriade's model these non-sonority-based phonotactics receive varied and sometimes ad hoc treatment--if they can be treated at all.

The second point raises the question as to whether the syllable template should be eliminated. The main objection to the template is that it stipulates such facts as basic syllable make-up and length. Because the template is not derived from or based on universal principles the facts which it contains seem arbitrary. It is difficult to relate templates from various languages other than in terms of syllable length. Furthermore, there is no separation of universal from language-particular facts (such as rule (1)). However, there is a sense in which the template gives a unified treatment of certain apparently arbitrary facts. For this reason I will now examine a recent treatment of Spanish syllable structure by Selkirk (1984) which incorporates both sonority and the syllable template.

3. Selkirk's Analysis

Selkirk proposes the sonority scale given in (13).<1> The numbers corresponding to the sonority indices are tentative, according to Selkirk, and future research is needed to confirm these values as well as the values of those sounds not included in (13).

(13)

sound	sonority index
a	10
e,o	9
i,u	8
r	7
l	6
m,n	5
s	4
v,z,ð	3
f	2
b,d,g	1
p,t,k	.5

Selkirk proposes the scale in (13) to motivate the idea that there is an n-ary feature [sonority] which captures better than binary features the natural classes which play a role in syllable structure. An example of one such class is given in (14) (Selkirk 1984:113).

(14)

Natural Class	Conditions on sonority index	Binary feature complexes
l,m,n, obstruents	6 $\geqslant$ n	$\left\{ \begin{bmatrix} +son \\ \{+lat \\ +nas\} \end{bmatrix}, [-son] \right\}$

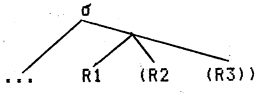
(Found in 3rd position of English rhyme)

Selkirk argues that one can readily refer to the class in (14) by means of the conditions on the sonority index, whereas to refer to it with binary features is clearly more cumbersome.

To account for possible syllable structures, Selkirk assumes the syllable template. The template characterizes the internal structure of the syllable, it indicates the maximum and minimum number of terminal positions, and identifies the terminal positions with reference names. It is to these terminal positions that the conditions on sonority apply.

In (15) is a partial template of Spanish syllables as proposed by Selkirk (p.126) and in (16) the corresponding conditions on sonority (p.130):

(15)



(16) If x is associated with R3 and y is associated with R2, then either

a. $SI(x) = SI(s)$
or b. $SI(x) \leq 7$ and $SI(x) < SI(y) - p$.

(16a) states that the last position (R3) may be s. Furthermore (16a) implicitly states that s may follow any R2 segment. (16b) has two parts. The first requires that R3 be a consonant; the second requires a certain minimum sonority difference p between R2 and R3. The particular value of p is unspecified by Selkirk since the absolute values of the sonority scale in (13) are not confirmed. However, p is language-specific.

To summarize, Selkirk accounts for permissible rhyme clusters in Spanish syllables by means of sonority conditions placed on terminal positions of the syllable template. Selkirk's analysis nicely accounts for the rhyme-internal constraints of Spanish, because her proposed scale includes both vowels and consonants. It does not have a rule of s-adjunction although one could argue that sonority condition (16a) is effectively stipulating the optional presence of s. Certainly condition (16a) is marked, since it may be adjoined regardless of the preceding consonant.

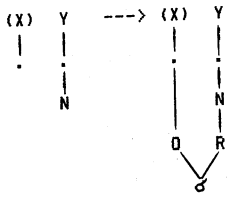
Selkirk uses the syllable template and not sonority conditions to constrain syllable length. The template also provides the internal structure of the syllable, a task which in Steriade's framework is accomplished by the syllable-building rules. One might ask then whether the syllable-building rules might not substitute for the template within Selkirk's analysis. This possibility is considered next.

4. A Proposal

In order to maintain core-syllable rules such as proposed by Steriade, it is necessary to impose some sort of sonority conditions on them. We have already seen that the MSD requirement will not work since we were unable to determine an appropriate feature-based sonority scale. I propose then to apply sonority conditions which make use of a numerical sonority scale to the core syllable-building rules.

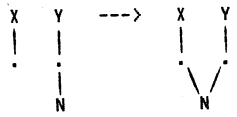
Recall that the Spanish data requires use of a dot tier so as to capture rhyme constraints on both V's and C's. Consequently rule (1), which captures the fact that CV syllables are maximally unmarked, must be reformulated since in its present formulation requires a CV tier. I will assume, following Levin (1983), that the nucleus is lexically specified. Thus rule (1) can be reformulated to build a syllable based on the nucleus node, as shown in (17).(2)

(17)



Prior to the application of rule (17) there is ordered a language-particular rule Glide-Incorporation which incorporates prevocalic glides into the nucleus. This is most likely the marked case since most languages have prevocalic glides in the onset. Glides in Spanish are those segments with a sonority index of 8 and which are adjacent to a more sonorous element. Thus Glide-Incorporation has the following form:

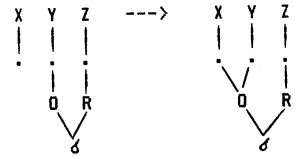
(18) Glide Incorporation:



Cond: SI(X) = 8.

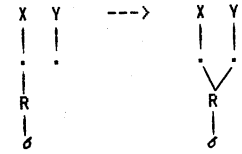
The proposed onset and coda rules are given in (19) and (20):

(19) Onset Rule:



Cond: iff SI(X) ≤ 2 and SI(Y) = 6,7.

(20) Coda Rule:



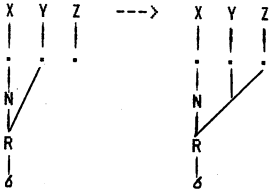
Cond: May only apply once.

The onset rule (19) will adjoin a stray segment iff the stray segment is a non-coronal fricative or a stop and the onset already contains a liquid. Its iterative application is limited by the sonority conditions placed upon it.

The coda rule (20) will attach any following stray segment to the rhyme. This reflects the fact that any segment may follow the nucleus whether it is simple or branching (as shown in (11a,c,d)). Rhyme length seems to be arbitrary to some extent, a fact which is accounted for by limiting the coda rule to only one application. This limitation is marked, but then the situation in Spanish seems to warrant it.

Finally, another language-particular rule must be posited. This one captures the marked fact of Spanish which is that a segment which follows a glide or consonant in the rhyme (cf.(11b)) must be an s.<3>

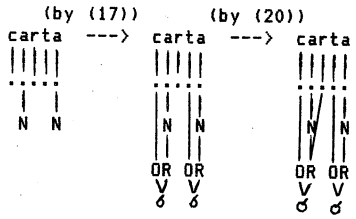
(21) S-Adjunction:



Cond: SI(Z) = SI(s).

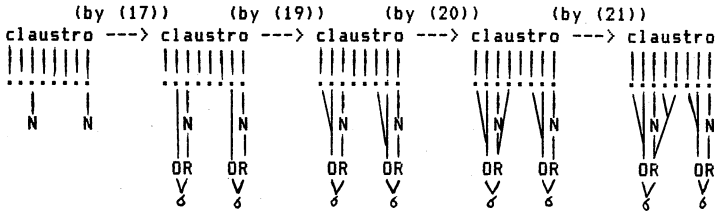
As an example of how the above proposal is to work, consider the following derivations. In (22) rule (17) first applies to build the maximally unmarked syllables. This step is followed by the coda rule (20). At this point all positions are syllabified.

(22) *carta* 'map' [karta]



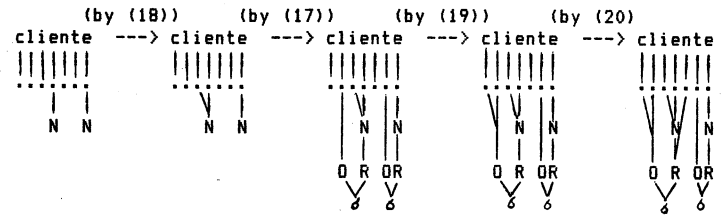
In (23) rule (17) first forms a syllable over la and ro but not elsewhere since there are no other appropriate sequences to which it may apply. By ordering, the onset rule (19) applies next and adjoins the stray k and the stray t to their adjacent syllables. Then the coda rule (20) applies to adjoin u. Rule (21) can then apply to adjoin the stray s.

(23) *claustro* 'cloister' [klaustro]



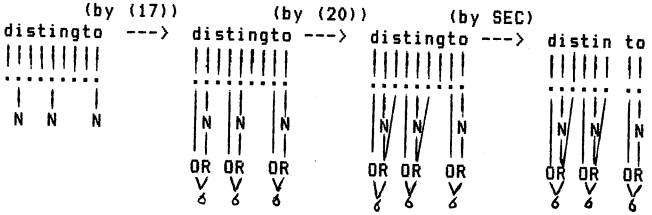
The derivation of (24) illustrates the application of Glide-Incorporation as there is a segment of sonority index 8 preceding the nucleus. The remaining steps are straightforward, consisting of the application of rules (17), (19) and (20) in that order.

(24) *cliente* 'client' [kliente]



The last example (25) shows the loss of an unsyllabified segment. After the application of the initial syllable-building rule (17), the coda rule applies adjoining one segment to each of the first two syllables. The stray g cannot be adjoined by rule (21) since the sonority index of Z does not equal the sonority index of s. The result is the loss of g by the Stray Erasure Convention (SEC) given above in (5).

(25) *distinto* 'distinct' [distinto]



cf. *distingir* 'to distinguish' [distingir]

To summarize, this analysis of Spanish accounts for Spanish syllable structure in the following way. Core syllables are produced by the set of syllable-building rules (17-21). Several of these rules have imposed upon them sonority conditions which refer to the scale in (13). These conditions reflect certain sonority constraints in Spanish, such as the conditions on rules (18) and (19). In addition there are certain arbitrary facts, such as the conditions on rules (20) and (21). The phonotactic constraints are given a uniform treatment, although constraints which might be labelled as arbitrary reflect this fact.

The analysis presented here incorporates the basic insights of both Selkirk's and Steriade's models. For example, Selkirk pointed out the problems with features in terms of accounting for those sonority classes which play a role in the phonotactics of a language. This insight is reflected in the numerical sonority scale which this analysis makes use of. Selkirk's model also provides a uniform treatment of phonotactics through her use of the syllable template. The analysis presented here also maintains a uniform treatment although without use of a template.

From Steriade's model this analysis maintains the idea of a set of core syllable-building rules which may be subject to sonority constraints. Furthermore, this analysis maintains separation of universal from language-particular facts. It also allows a relatively simple treatment of languages with mirror-image onset and coda structure. For these languages the onset and coda rules would have the same set of sonority conditions placed on them. Finally, this analysis shows that Steriade's basic insight that syllable templates are unnecessary is a correct one.

FOOTNOTES

**I would like to thank Keren Rice for her comments and suggestions on previous drafts of this paper.

<1> Selkirk also includes θ in her scale. I have omitted it here since this is not a sound occurring in the dialects of Spanish being considered here.

<2> The dependency of rule (17) on the N node fits in with the idea that the nucleus is in some sense the 'head' of the syllable, cf. Levin (1983), Lowenstamm and Kaye (1982).

<3> As the formulation of rule (21) suggests, it can only apply when the nucleus is non-branching. A less ad hoc formulation of (21) is possible given a different approach to syllable building. This approach is pursued in Carlyle (in prep.).

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