

Whence Sonority? Evidence from Epenthesis in Modern Irish*

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0. Introduction

In much recent discussion on the construction of syllables has appealed to the notion of the *Sonority Hierarchy*. The leading idea behind this notion is that the pattern of rising sonority, a sonority peak and then falling sonority makes direct reference to a rank ordering of segments based on their relative sonority. Following Clements (1990), Rice (1992), Harris (1990), and Larson (1992), I will provide evidence that the calculation of sonority is determined not by an arbitrary ranking, but rather upon a simple calculation of featural content. Thus the sonority contour is determined directly by the feature structure of the segment. I will also make two additional claims. 1) I will show that the phenomenon of minimal distancing between adjacent consonants is a subcase of the sonority contour, where the phonology is allowed to refer to the complexity of one specific featural node. 2) I will also claim that the calculation of sonority is not one of simple feature counting, but one which follows from the markedness relations in the feature geometry. To do this I will be making reference to the epenthesis facts of Modern Irish. In section 1 of this paper, I will outline an incomplete system for the description of sonority contours and minimal distancing constraints. In section 2, I will look at the facts of Irish in light of this framework. Finally, in section 3, I will show how the sonority sequencing facts of Irish are best explained in terms of a feature geometry which expresses markedness relations.

1. A System of Syllabic Relations

If sonority plays some role in determining what the syllabic relations hold for a given word, in order to discuss sonority we must first determine the

* This paper has benefited greatly from discussion with many people: most notably are Morris Halle, Michael Kenstowicz, Alec Marantz, Ken Hale, Tony Bures, Dónall Ó Baoill, John McCranie, Colin Phillips, Heidi Harley, and Shawn Kern. This work was first presented before the Phonology Morphology Workshop at MIT and I would like to thank my classmates for their helpful comments. An earlier version of this paper was developed at the University of Toronto, and I would like to thank Keren Rice, Tom Wilson and Elan Dresher for their advice on that work. The research for this paper was partially supported by a grant from the Social Sciences and Humanities Research Council and by a grant from the Alberta Heritage Fund.

nature of these syllabic relations. In this section, I wish to outline a system for describing these relations.¹

1.1. Some Initial Assumptions About Syllabic Relations

Most traditional accounts of syllable structure assume that there is some hierarchical relationship between syllabic constituents (see, for example, Selkirk (1982), Goldsmith (1990), Bures (1989)). In the face of evidence from stress, weight, and length, this assumption is likely to be correct. With respect to the sonority relations that hold between segments, however, it can be noted that no hierarchical relations are necessary. Linear adjacency and simple syllable boundary marks are sufficient since only adjacent segments can affect the positioning of the others within a constituent. Consider, for example, the abstract diagram in (1)

1. V₁ C¹ C² C³ V₂

The constituency of each consonant in this representation is determined by the sonority of the neighboring consonants. There are no long-distance dependencies among them (as would be expected under a hierarchical account) (See Kaye Lowenstamm and Vergnaud (1985, 1990) for a contrasting view). The sonority of C³ can determine whether C² forms a constituent with it, but cannot affect C¹. For this reason, I will refer in this paper only to the relation of linear adjacency, all the while assuming that these strings have hierarchical structure irrelevant here.

We can immediately make another important observation about syllabic relations, that the sonority of vowels does not affect the constituency of consonants (at least for English, French and Irish). The relative sonority of a vowel will not affect how the consonants are syllabified. In languages which have *minimal distancing* constraints, a VC sequence always satisfies the constraint. From this we can conclude that vowels are “special.” This may correlate with the fact that vowels are consistently syllable peaks and that every syllable must have a peak. Whatever the explanation of this fact is, we must be sure that our grammar does not allow a vowel to affect the constituency of the consonants that surround it.

I will thus make the following two assumptions about how segments are syllabified.

- i) Vowels form the head of the syllable and do not affect the correct syllabification of consonants

¹This system owes a heavy debt to Idsardi (1992) whose general framework of metrification gave inspiration to this system of syllabification, and to Bures (personal correspondence) who pointed out that extension of Idsardi’s system was plausible for syllable structure.

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- ii) The only relations necessary for determining constituency are linear ones.

1.2 A System of Adjacency Relations and Constituency

Let us assume for the moment that there is some principle in the grammar that defines the structural positions in a syllable. For the purposes of this paper, we need only define the notion of “syllable peak” and define relations that associate consonants to this peak. For more refined notions of how these relations might be encoded I refer the reader to Bures (1989), Carnie (1992), and Clements (1990).

Let us start by considering the notion ‘Syllable peak’. There are two schools of thought on how this term can be encoded. One school (that advocated by e.g. Bures (1989), Carnie (1992), Kaye Lowenstamm and Vergnaud (1985) etc.) holds that *syllable peak* is an inherent property of certain segments (typically vowels). The other school (as exemplified in the followers of Moraic Phonology (such as Hayes 1988) and Harmonic Phonology (Goldsmith and Larson (1990), Larson (1992)) holds that being a syllable head is a derived phenomenon. Comparing segments directionally, one can check the sonority of each element to that of its neighbors. An element with more sonority than both of its neighbors is a sonority peak. In Irish, there is no evidence to distinguish between these two schools of thought, as only vowels can function as syllable peaks. For convenience, I will assume the somewhat simpler inherent property approach. In particular, I will assume that a syllable head is simply an element marked with the feature [VOCALIC]:

- 2. *Syllable Peak.* (for Irish) an segment is a syllable peak if it bears the feature [VOCALIC]

This definition seems naïve in the face of languages like Berber, Bella Coola, and Cayuga, all of which allow non-vocoid elements to function as syllable peaks. Given these languages, the derived peak approach is likely the correct approach. However, since Irish does not have such complications I will not pursue this notion here, and assume the simpler (2) above.

We can now define other syllable positions relative to these heads. I will define these relations linearly, although hierarchical systems might ultimately be preferable. The following is a procedure for labelling consonantal positions:

- 3. *Principle of Consonant Labelling*
Given a Syllable Peak: N, a Consonant is labelled C^{x+1} , where x is the number of segments intervening between it and N. Labelling stops when the procedure hits another N.

An abstract example of this is given in (4)

- 4. C^3 C^2 C^1 N C^1 C^2 C^3

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Notice that under this system consonants appearing between two vowels will receive two different labellings. Consider, for example, the labellings for the word “example”, given in (5). In this diagram each line represents the labelling for a different vowel.

5.	/e	g	z	a	m	p	E	l/
	N	C ¹	C ²					
		C ²	C ¹	N	C ¹	C ²		
					C ²	C ¹	N	C ¹

In order to characterize the sonority contour, we must decide which of these labellings is correct. If we were to make a statement like “C^x must be more sonorous than C^{x+1}” with such multiple labellings we would be led to a paradox, since each of a pair of consonants (like /gz/ in example (5) above) is C^x and each is C^{x+1}. They cannot both be more sonorous than the other. This leads us to the notion of constituency. I propose a system whereby constituent boundaries are freely inserted between segments, the representations are then subject to certain universal and language-specific constraints. This process is formalized by the following rules (6b and c are after Hooper 1972):

6. *Rule of boundary insertion* (Universal)
 - a) Insert a syllabic boundary]]_σ, between any two segments
 - b) place a boundary [_σ at the left edge of a word
 - c) place a boundary]]_σ at the right edge of a word

As discussed above, we want to be sure that consonant labels are only relevant within the constituent to which they belong². For this we can revise the labelling principle given above in (3).

7. *Principle of Consonant Labelling* (revised)

Given the structure [_σ...C...C... N... C... C] , a Consonant, C, is labelled C^{x+1}, where x is the number of segments intervening between it and N

1.3 Constraints on Syllabic Relations

Our system of bracket assignment above is powerful and allows many illformed syllable structures. To minimize this problem, I will posit two different types of constraints: constraints on constituent construction and constraints on sonority relations. Each of these will appear as either universal and language specific. Constraints on constituent construction will place limitations on the placement of brackets, whereas constraints on sonority relations will make reference to the labelling of consonants based on those

²This is not quite true. See below for a discussion of cross-syllable dependencies.

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brackets. In this section, I will also attempt to restrict the language specific constraints to a limited set.

1.3.1 Constraints on Constituent Construction (Bracketting).

The grammar, as it is stated thus far, overgenerates syllable structures in a consistent way. Mainly, it allows syllabic constituents without nuclei, and those with more than one nucleus:

8. a) $[\sigma C][\sigma C][\sigma C][\sigma N][\sigma C][\sigma C][\sigma C]$
 b) $[\sigma C C][\sigma C N][\sigma C C C]$
 c) $[\sigma C][\sigma C C][\sigma N C][\sigma C C]$
 d) $[\sigma C N C N C]$

All of the brackettings of the string in (8) are illicit, since there are syllabic constituents without nuclei. From this we can assume the following universal principle of grammar:

9. All syllables must have exactly one head (nucleus)

Or more formally:

10. *The Syllabic Head constraint* (Universal)
 * $[\sigma C \dots C]$ where ... contains *NO* nucleus
 * $[\sigma \dots N \dots N \dots]$

This constraint ensures that all freely bracketted strings of segments contain a nucleus.

All languages allow syllables with at least one onset element. There is no language which disallows prevocalic consonant, whereas languages which disallow postvocalic consonant common. In fact, it has been observed that languages generally require that a consonant immediately preceding a vowel belong to that vowel's syllable³. This is the *onset requirement*. The system as outlined in section 1.2 allows brackettings where the constituent boundary falls in between the vowel and the consonant that precedes it. We must disallow such brackettings. The following constraint is presumably analogous to Clements' (1990) *Sonority Dispersion Principle*

11. *Onset Constraint* (Universal)
 * ... C $[\sigma N$...

(10) and (11) ensure two important aspects of syllable structure, that all syllables have nuclei and all require onsets where possible. There are also many

³Bosch (1990) posits an exception to this for the Barra Dialect of Scots Gaelic.

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language-specific constraints on bracketting (ignoring sonority restrictions for the moment) For example, many languages allow only CV syllables (e.g. Japanese), in these languages there is presumably a constraint ⁴ like the following:

12. *Coda Constraint* (language specific)
* ... C_σ]

This constraint may be formalized into UG in the form of a parameter; languages either have this constraint or they don't. A language like English won't have it, whereas a language like Japanese will. Given the positive evidence requirement on the learnability of parameters we might assume that the unmarked setting of this parameter is "on". When a child hears evidence of closed syllables she switches the constraint off. We can thus restate (12) as the parameter in (13):

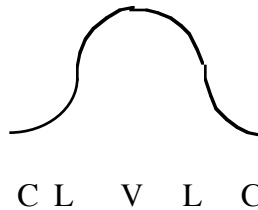
13. *Coda Parameter* (unmarked setting: ON)
*... C_σ]

Presumably all other constraints on bracketting (if there are any) take this general form.

1.3.2 Constraints on Sonority

As mentioned above one of the most striking features of syllable structure is the fact that they always have a sonority contour. Syllables have the form in (14):

- 14.



Our system of syllabification should of course capture this fact. We must rule out sequences where the sonority rises then falls then rises all within the same syllable. For example the putative syllable [σ]patv] should be ruled out since /l/ has greater sonority than /p/ and /v/ has greater sonority than /t/. To do this we can posit a constraint on sequencing. I am using here the double bracket

⁴I am ignoring here possible exceptions to CV syllable restrictions such as geminate clusters and moraic nasals in Japanese (see Itô 1989) for more details. A constraint like (12) will clearly need fine tuning in the face of such facts.

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notation: $[[\]]$ of Bures (1989) to indicate the level of sonority of the element within those brackets. How exactly this sonority value is determined will be discussed in sections 2 and 3. For now we can simply assume that these values are numerical, and that larger numbers correspond to greater levels of sonority.

15. *Sequencing Constraint* (Universal)

For two linearly adjacent segments C^x and C^{x+1}
 $*[[C^x]] - [[C^{x+1}]] < 0$

This constraint requires that sonority of a consonant closer to a Nucleus be greater than or equal to the sonority of its neighbour which is further away from the nucleus.

The constraint as it is formulated thus far still allows unacceptable brackettings of sequences. Consider for example the bracketting given in (16) of the English word “encrypt”:

16. $[_\sigma e n k] [_\sigma r i p t]$

This bracketting is illicit, the /k/ should belong to the second syllable. This is reflected in the traditional principle of “Maximize onsets”. We must therefore write a constraint that rules out such brackettings. Rice (1992) formulates this constraint, after Bures (1989), in a way that states that a segment is allowed in a coda only if it is of greater sonority than the consonant that follows it. This relation then is one that actually holds between different potential syllabic constituents. After Bures (1989) and Kaye Lowenstamm and Vergnaud (1985) I will thus call this a “Cross-syllable dependency”. This name is obvious if we consider the following hypothetical case. The status of the segment X as a coda in the first syllable is determined by the sonority of segment Y, which by the onset constraint given above, must be an onset.

17. $\dots X] [_\sigma Y Nuc \dots$

If X is less sonorous than Y then this is an illicit bracketting -- the two segments should form a complex onset. If X is more sonorous than Y, then this is an acceptable bracketting -- X could not participate in the onset of the second syllable, therefore it must be part of the first syllable. In these terms the maximize onsets principle looks strikingly similar to the constraint on sonority contours. The generalization to be drawn here is that the sonority sequencing constraints that hold within a coda also hold between the final codal element and the following onset. This then derives the maximize onset principle. As will be seen below, evidence for this generalization will also be found in the fact that it also helps us to account for the environments of minimal distancing constraints.

How exactly are we to encode this additional constraint? I propose that this follows directly from the sonority sequencing constraint given above in (15) if we allow the following modifications to our labelling procedure:

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18. *Principle of Consonant Labelling* (final)

- a) Given the structure $[\sigma \dots C \dots C \dots N \dots C \dots C]$, a Consonant, C, is labelled C^{x+1} , where x is the number of segments intervening between it and N
- b) Given the structure $\dots C^y$ $[\sigma C^z]$, Constituent C^z is given the second label C^{y+1}

This means that the leftmost consonant in any given syllable may be given two labels: one for its own syllable, and one for the syllable that precedes it. Consider the following abstract example:

19.	C^3	C^2	C^1	N_1	C^1	C^2	C^3	N_2	X
	[X	X	X]	X	A]	[B	N ₂	X]
							C^1		C^2

This allows us to account for cross-syllable dependencies and derive the maximize onset effect. The sonority sequencing constraint will rule out such a representation when B has greater sonority than A. The difference between the $C^3(B)$ and $C^2(A)$ will be greater than “0”, so the representation will be ruled out. This will force A to form a complex onset with B.

In addition to this basic universal constraint given above in (15), there are presumably language specific variations. These are the minimal distance constraints found in many languages. Minimal distance constraints hold that not only must a syllable have a sonority contour of the type in (14), but that there must be a certain “distance” or difference in the sonority between adjacent consonants. For example, Harris (1983) shows that onset sequences of obstruent-nasal and nasal-liquid are illformed, whereas Obstruent-liquid onsets are acceptable. Similarly, evidence from vowel length alternations in Icelandic (Kiparsky 19??) suggests that a sequence of a voiced stop then liquid forms an illformed onset. As a contrary example, Kaisse (1988) points out that stop-stop sequences in Greek are not acceptable in Codas, the first of these two consonants will consistently spirantize to a fricative. Each of these examples shows a case where two adjacent consonants must be separated by a certain sonority distance. Irish is another language which has such a constraint (as will be discussed below at great length). In the coda a sonorant followed by a voiceless stop is acceptable, but one followed by a voiced stop, a fricative, or another sonorant is unacceptable and epenthesis applies between the two consonants. What is of special interest here is that in Irish (like Greek) this minimal distancing constraint is only true of the coda. Onset sequences are not subject to it:

- 20. a) *[bolb] (cf. [bolEb]) “caterpillar” *bolb*
- b) [blah] “bright” *blath*

This can be compared to the facts of Icelandic and Spanish where the minimal distancing constraint holds only on onset clusters and not on coda clusters. From this we can conclude that, unlike the general sonority sequencing effects,

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minimal distance effects are not symmetrical and must have a directional component. I propose the following parameters to account for these effects. I will not specify, for the moment the value of the variable δ , the minimal distance, leaving this for discussion in section 3.

21. *Minimal Distance Parameter* (language Specific)
- a) on/off (unmarked: ON)
 - b) Right of nucleus/Left of Nucleus (Unmarked: ??)
- $$*[[C^x]] - [[C^{x+1}]] < \delta$$

With our revised labelling procedure, which derives the maximize onset constraint, we would expect cases where a minimal distancing constraint holds between a coda and the following onset (the heterosyllabic cases). This is exactly the case for Irish clusters:

22. a.	seirbhís	<i>service</i>	/Servi:S/[Se:rEvi:S]	
b.	confadh	<i>anger</i>	/konfE/	[konEfE]
c.	Alba	<i>Scotland</i>	/albE/	[alEbE]
d.	dorcha	<i>dark</i>	/dorxE/	[dorExE]

Interestingly, in some languages (such as Winnebago or Ponapean (see Bures (1989) for more details), the minimal distancing that occurs across a syllable boundary is weaker (requires a smaller sonority distance) than that of within syllables. Since I am primarily interested in the facts of Irish here, I will not attempt an account of such differences in minimal distancing effects, but leave them for future research.

There is an additional set of restrictions similar to that given in (21) which holds in many languages, this is the constraint that consonants in the onset or the coda may not share a place of articulation. For example, in English, the following onset sequences are not legitimate (see Borowsky (1986) for further discussion):

23. *pw *bw *dl *tl

Such illicit sequences are not obviously the result of a minimal distancing constraint. Take for example the sequence */dl/. This sequence is no less distant than the acceptable cluster /bl/. In English complex onsets, elements cannot share the same place of articulation⁵. To account for this we can posit the following parameter:

⁵The onsets /tr/, /dr/, /str/, and /sl/ are all obvious exceptions to this generalization. These might be accounted for by appealing to theories of underspecification, in which /r/ would not have a place specification as well as to a theory of syllabification which allows /s/ appendices to syllables.

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24. *Anti-Homorganicity Constraint* (Parameter)
a) on/off (unmarked ON)
b) Right of nucleus/Left of Nucleus
* C^x C^{x+1}
 | |
 [place] = [place]

This concludes my discussion of the principles of bracketting and labelling and the constraints thereon. However, before preceding to the facts of Irish, I would like to consider two additional residual issues, that of non-sonority, non-bracketting syllabic constraints and a brief discussion of geminate and near-geminate exceptions to the constraints discussed above.

1.4 Residual Issues: Other constraints and Geminates.

1.4.1 Other constraints

In section 1.3 above I give a restricted set of constraints on syllabic bracketting. These are either universal or parametric in nature and are all highly general. In this short section, I would like to point out briefly another type of constraint that is found in natural language. I will not attempt to deal with it in a systematic way here but it is important for a complete account of syllabic structures.

There are languages which require that syllables have a certain quantity of rhyml material in certain metrical positions, or alternately that words have a certain quantity of rhyml material (minimal word constraints). These constraints presumably govern lengthening and deletion processes. In Irish, epenthesis above does not apply when the nucleus preceding the sonorant is long. I will assume that these types of constraint follow from the heirarchical structure which I have been tacitly assuming sits above the labelled brackettings discussed above. Such constraints make direct reference to this heirarchical structure. Since this is not directly relevant to the discussion of sonority constraints I will not make further mention of them here.

1.4.2 Geminates and Near-Geminates: Binding.

The most well known set of exceptions to the sonority and bracketting constraints concern geminates and near-geminates. Japanese is normally a CV language; it does allow CVC syllables, however, when the last C is the first part of a geminate with the following onset or shares primary place of articulation with that segment.

25. a. kap.pa *legendary being* (*kap.ta)
 b. tom.bo *dragonfly* (*tog.bo)
 c. gak.koo *school*
 d. taN.gae *thought*
 e. kit.te *stamp* (Itô 1982)

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Similar facts in Irish are found: consonant sequences that share primary place of articulation are immune to the minimal distancing constraints discussed above. This is evidenced by the fact that the repair process of epenthesis does not apply in these clusters:

26. a.	fearnóg	<i>alder</i>	[farno:g]*[farEnog]
b.	bord	<i>table</i>	[bord] *[borEd]
c.	banc	<i>bank</i>	[baNk] *[baNEk]
d.	cursa	<i>course</i>	[kursE] *[kurEsE]
e.	calra	<i>calorie</i>	[kalrE] *[kalErE]

Bures (1989) accounts for such facts by appealing to a notion of inheritance of prosodic licensing: Binding. Bures assumes a system where all segments must be “licensed”. By this he means that they must be incorporated into the prosodic structure dominating the segmental tier⁶. Using evidence from reduplicative templates, Bagemihl (1992) argues that Bella Coola is a language where segments do not have to be incorporated into syllable structure. From this we may conclude that the notion of “prosodic licensing” is a parameterized one. Some languages, like English, require all segments to be licenced, whereas others (like Bella Coola) apparently do not.

- 27) *Principle of Prosodic Licencing* (Parameter, unmarked ON)
 All segments must be part of the syllable structure of a word

Segments for which all brackettings and labellings result in violations of at least one constraint will be unlicensable. They will not participate in the prosodic structure of the word. For such a segment to surface then, a repair strategy must occur. This strategy may take the form of Epenthesis (like in Irish and Japanese), Stray Erasure (as in Diola Fogny (Sapir 1965)), or Metathesis (like in Sidamo (Vennemann 1988)). Bures proposes an over-riding strategy of licencing that is allowed to occur before the repair strategies are called into play. This is Binding. The central notion behind binding is that if a segment is linked by some specific featural node to another segment which is licenced then that segment “inherits” the licensing of that segment.

28. *Binding* (Parameter)
 A segment S, will be considered licensed, independent of
 bracketting considerations iff
 a) It is linked by a Φ node (parameterized) to a segment S'
 AND b) S' is a licensed segment.

Let us take Japanese as a test case here and see how this works. I will use the word [kappa] 'legendary being' as an example. Japanese is a CV

⁶Note that this is a very different notion of “prosodic licensing” than that espoused in Goldsmith (1990). Licensing here means only “participates in prosodic structure”, whereas for Goldsmith the term means “allowing specific features to appear in specific syllabic positions”. I will follow Bures’ use of the term here.

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language, so it has the coda constraint turned on. For this reason, brackettings like:

29. [k a p][p a]

will be illicit. There is no bracketting which licences the first [p].

30. [k a]p [p a]

This [p] however shares a [PLACE] node with the following [p] which *is* licensed. For this reason the representation in (30) may surface. (I will represent “bound” segments in bold face):

31. [k a] **p** [p a]

The more complex case of Irish will be considered in section 2.

2 Epenthesis in Modern Irish

2.1 The Syllable structure of Irish.

Irish syllable structure is similar to that of English; in fact, it is often more permissive. Syllables of the type V, V:, VC, V:C, VCC, V:CC, CV, CV:, CVC, CV:C, CCV, CCV:, CCVC, CCV:C, CCVCC, CCV:CC, sCCVC..., sCCV:C..., etc. are all found both word internally and at word edges. This can be seen in the data in (1). (1a-x) shows the possible expansions of the rhyme in both word internal positions (c,d,g,h,k,l,o,p,s,t,w,x) and at word edges (a,b,e,f,i,j,m,n,q,r,u,v). This is shown to be true of both syllables with no onset (a-l) and those with one (m-x). (1y-hh) shows the different onset sequences that may appear with different rhymes. (throughout this paper “.” will be used to denote a syllable boundary; /S/ is the palatal alternant of /s/ and appears in the same syllabic contexts as /s/):

32. a.	a	<i>his</i>	[E]	V/ __#
b.	é	<i>him</i>	[e:]	V:/ __#
c.	imeacht	<i>going</i>	[i.m]Ext	V/ __.C
d.	éadach	<i>clothes</i>	[e:.dEx]	V:/ __.C
e.	ag	<i>at</i>	[ek]	VC/ __#
f.	ár	<i>our</i>	[a:r]	V:C/ __#
g.	ildathach	<i>iridescent</i>	[il.dahEx]	VC/ __.C
h.	aerga	<i>ethereal</i>	[e:r.gE]	V:C/ __.C
i.	acht	<i>enactment</i>	[axt]	VCC/ __#
j.	áirc	<i>ark</i>	[a:rk]	V:CC/ __#
k.	iarndóid	<i>iron fist</i>	[i.Ern.do:dʲ]	VCC/ __.C
l.	ardmháistir	<i>headmaster</i>	[a:rd.va:SʲErʲ]	V:CC/ __.C
m.	do	<i>to</i>	[do]	CV/ __#
n.	dó	<i>to.3.sng</i>	[do:]	CV:/ __#
o.	dada	<i>nothing</i>	[da.dE]	CV/ __.C

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p.	cóisir	wedding feast	[ko:.Sir]	CV:/__C
q.	mac	son	[mak]	CVC/___#
r.	bád	boat	[ba:d]	CV:C/___#
s.	garda	police	[gar.dE]	CVC/___C
t.	fádsaolach	easygoing	[fa:d.silEx]	CV:C/___C
u.	cart	to tan	[kart]	CVCC/___#
v.	corúisc	stupid woman	[ko.ru:Sk]	CV:CC/___#
w.	dearschnaitheacht	excellence	[dʲars.knahExt]	CVCC/___C
x.	ceardchumann	trade union	[kʲa:rd.xumEn]	CV:CC/___C
y.	creachán	little potato	[kra.xa:n]	CCV
z.	grátáil	grating	[gra:.ta:lʲ]	CCV:
aa.	cross	cross	[kros]	CCVC
b..	prás	brass	[pra:s]	CCV:C
cc.	planc	spot	[plaNk]	CCVCC
dd.	práisc	slob	[pra:Skʲ]	CCV:CC
ee.	stad	to stop	[stad]	sCV(CC)
ff.	scéal	story	[Ske:l]	sCV:(CC)
gg.	script	script	[Skriptʲ]	sCCV(CC)
hh.	strást	hitherto	[stra:st]	sCCV:(CC)

Obviously, Irish, like English, is fairly liberal in its syllable construction with the theoretically maximal syllable seen in (32hh): sCCV:CC (eg. [stra:st])⁷. In this sense then Irish behaves exactly as expected with respect to the sonority contours. With the additional stipulation, that like English it allows /s/ appendices at the beginning and end of each syllable. In fact, Irish is often even more permissive than English. For example, unlike English, Irish also allows the onset clusters: /dl/, /tl/, /tn/, /kn/, /gn/, /sr/, /skn/, /Skn/⁸. This is seen in the data in (33)

33. a.	dlí	lawyer	[dli:]
b.	tlacht	weak	[tlaxt]
c.	tnúth	envy	[tnu:h]
d.	cnoc	hill	[knok]
e.	gneas	sex	[gnʲas]
f.	srón	nose	[sro:n]
g.	firinsneach	masculine	[firinʲSkʲnʲEx]
h.	tionscnamh	origin	[tʲionsknu:]

⁷There are two points of contention about this claim. (1) Since Irish allows Cs sequences in Codas, the predicted maximal syllable should be sCCV:CCs. This sequence, however, never occurs in the language. We might attribute this to the fact that Irish has no /s/ suffix. Most words in English that have the CCs coda are a result of some form of /s/ affixation (exceptions being words like “lynx” and “manx”). Since there no /s/ affixes this might create an accidental gap in the inventory. (2) The single word I have found to fit this maximal syllable is in fact a contraction of the words “gus trasta” [gus trastE]. Ó Donáill, however, lists it as a separate word.

⁸There are, however, no /stl/, /Stl/. A possible exception is the cleft clitic and a /tl/ initial word: 'S tlaith... /stla:/ 'it is weak'. My thanks to John McCranie for pointing this and (33g and h) out to me.

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In codas, many clusters are allowed. For example, Irish permits (under certain restrictions to be discussed below) sonorant-sonorant and sonorant-obstruent clusters in codas.

34. a.	corp	<i>body</i>	[korp]
b.	cairn	<i>pile of rocks</i>	[ke:rn]
c.	planc	<i>spot</i>	[plaNk]

Similarly, it allows the coda fricative-stop clusters of the form /st/, /St/, /xt/, /sk/, /Sk/, /ft/⁹

35. a.	ceacht	<i>lesson</i>	[kʲaxt]
b.	riasc	<i>marsh</i>	[riEsk]
c.	réisc	<i>marsh.gen</i>	[re:Skʲ]
d.	teist	<i>testimony</i>	[tʲeStʲ]
e.	tost	<i>silence</i>	[tost]
f.	seift ¹⁰	<i>device</i>	[Se:ft]

All of these facts are accounted for if we assume the following parameter settings:

36. Principle of Prosodic Licencing (ON)
The Syllabic Head constraint (Universal)
Onset Constraint (Universal)
Coda Parameter (OFF)
Sequencing Constraint (Universal)
Anti-Homorganicity Constraint (OFF)
Appendix: /s/ & /S/

Thus, Irish shows a wide variety of syllable structures. This variety, however, is quite restricted in many regards. This will be seen in the following section, where the process of epenthesis is examined.

2.2 Primary Epenthesis:

Irish has two processes of epenthesis: primary¹¹ (“*an chéad ghuta cúnta*”) and secondary (“*an dara guta cúnta*”). The two processes are different in many ways. For example secondary epenthesis is an optional process which applies in different environments from the obligatory primary epenthesis. Also, secondary epenthesis only applies in onset clusters. In this paper I will look at

⁹Irish may, in fact, allow other fricative-stop clusters such as /sp/ codas. I was unable to find any examples of these in a search of Ó Donáill; and again, I will not attempt to account for these gaps. I will assume that this is an accidental gaps

¹⁰Thanks to John McCranie for pointing this example out to me.

¹¹For alternative analyses of this phenomenon see Cyran (1992), Ní Chiosáin (1990), (1991) and for the analogous process in Scots Gaelic see Bosch (1990) and Clements (1986).

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only the primary epenthesis. Roughly speaking, an epenthetic vowel is inserted between two consonants, where the first consonant is a sonorant.¹² This is seen in (37). It happens within morphemes (37a), between compounds¹³ (b), between affixes and stems (37c), at word edges (37d), before inflectional suffixes (37e), in borrowed words (37f), and in the middle of words (37g & h and i):

37. a.	bolg + chaint	<i>ventriloquism</i>	/bolg+xajnt/	[bolEgxajnt]
b.	sean + mhathair	<i>grandmother</i>	/SEn + wahEr/	[SEnEwahEr]
c.	an + mhaith	<i>very good</i>	/En+wah/	[EnEwah]
d.	gorm	<i>blue</i>	/gorm/	[gorEm]
e.	ainmneacha	<i>names</i>	/an ^h m ^h naxE/	[an ^h E.m ^h n ^h axE]
f.	seirbhís	<i>service</i>	/Servi:S/[Se:rEvi:S]	
g.	confadh <i>anger</i>		/konfE/	[konEfE]
h.	Alba	<i>Scotland</i>	/albE/	[alEbE]
i.	dorcha	<i>dark</i>	/dorxE/	[dorExE]

The process applies both coda internally (37d and e) and between a coda and the onset of a following syllable (37f-i). It never occurs in onset clusters¹⁴. This is seen in (38) below.

38. a.	bris	<i>break</i>		[briS]
b.	dlí	<i>law</i>		[dli:]
c.	achrann	<i>entanglement</i>	[axrawn]	
d.	mná	<i>women</i>		[mna:]

The second element cannot be a voiceless stop. When this happens, epenthesis does not apply:

39. a.	corc	<i>Cork</i> (place name)		[kork]
b.	corca	<i>people</i>		[korkE]
c.	corp	<i>body</i>		[korp]
d.	caile	<i>chalk</i>		[kajl ^h k ^h]

This is clearly a minimal distance constraint. Epenthesis applies when the sonorant is followed by a voiced stop, fricative, nasal or liquid, but not when it is followed by voiceless stop. This constraint holds in the coda only. We can thus set the first two parameters of the minimal distance constraint:

40. *Minimal Distance Constraint:*

- a) ON
- b) Right of nucleus

¹²For the purposes of this paper I will use the following abbreviations L=sonorant, C=consonant, B= any consonant that is not a voiceless stop, P = voiceless stop, D= coronal. The basic environment for epenthesis can thus be described with the abbreviation /L__B.

¹³This is not true of all dialects. See Ó Siadhail (1989) for discussion.

¹⁴However, see below for a discussion of secondary epenthesis which does occur in onset clusters.

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We must now determine the value of the minimal distance parameter δ . Let us start by assuming the following sonority hierarchy, despite the fact we will ultimately reject such hierarchies below.

41. *Irish consonantal sonority scale:*

1. Voiceless stops
2. Voiced stops
3. Voiceless fricatives
4. Voiced fricatives
5. Sonorants

Given this scale, a sonorant-consonant sequence which is distant by 4 on this scale is acceptable, as in /korp/ ($[[\text{sonorant}(5)]] - [[\text{vls stop}(1)]] = 4$). However, one distant by 3 is unacceptable, as in /bolb/ ($[[\text{sonorant}(5)]] - [[\text{vcd stop}(2)]] = 3$). We can therefore conclude that the value of δ for Irish is $|4|$. We can thus tentatively set the minimal distancing parameters as in (42)

42. Minimal Distancing Constraint (tentative):

- a) ON
- b) Right of nucleus
- c) $\delta = |4|$

Questions about the learnability of parameters like (40c) aside, we can now see how these parameters account for the locations of epenthesis in Irish. Let us consider the word *confadh* “anger” /konfE/ [konEfE]. Given the *syllabic head constraint* and the *onset constraint*¹⁵, let us consider only two possible brackettings of this word’s underlying form:

43. a. [k o n] [f E]
b. [k o] [n f E]

As it will turn out both of these are unacceptable brackettings. Let us consider (43a) first. This bracketting will have the following consonant labellings:

44. [k¹ o n¹] [f²₁ E]

The /f/ here receives two labels, this is, as the reader will recall, to ensure the principle of maximize onset. If we apply the δ formula to this bracketting, we see that the minimal distance is not met here. The difference in sonority is less than the requisite $|4|$. Thus this syllabification is ruled out.:

45. $\frac{[[n]] - [[f]]}{5 - 2 = 3} \quad (C^x - C^{x+1})$
3 < 4 Therefore MDC not met

¹⁵These will rule out brackettings like [ko][n][fE] and [konf][E]

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Let us now consider the alternative bracketting:

$$46. \quad [k_1 \text{ o }] [n_1^2 \text{ f}^1 \text{ E}]$$

If we check the δ formula here, we find that, again, the minimal distance constraint is not met:

$$47. \quad \begin{array}{l} [[f]]-[[n]] \quad (C^x - C^{x+1}) \\ \underline{2 - 5 = -3} \\ -3 < 4 \text{ Therefore MDC is not satisfied} \end{array}$$

It is thus the case that neither of the likely brackettings for this word will work. Epenthesis applies to repair the word by breaking up the adjacency relation between the two consonants which are too close in sonority, yet insuring that all elements are prosodically licensed.

$$48. \quad [ko][nE][fE]$$

Let us now see what happens with a word where the unlicensable element occurs at the word edge. Consider the word *gorm* “blue” /gorm/ [gorEm] for example. (49) is the only bracketting which does not violate the Head constraint or the Onset constraint. It also satisfies the Sequencing constraint.

$$49. \quad [g \text{ o } r^1 \text{ m}^2]$$

Applying the δ formula to this representation results in a violation of the minimal distancing constraint.

$$50. \quad \begin{array}{l} [[r]]-[[m]] \\ \underline{5 - 5 = 0} \\ 0 < 4 \end{array}$$

This word then cannot be bracketted as such and epenthesis must apply to save the representation by breaking up the adjacency between the /r/ and the /m/, thus prosodically licencing each of the segments:

$$51. \quad [go][rEm]$$

2.3 Binding

In this subsection I will consider one final parameter setting, that of binding, which will explain the homorganicity restriction on epenthesis. In Irish, epenthesis does not apply when the sonorant and other consonant are homorganic in primary place of articulation:

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- | | | | |
|--------|---------|----------------|-----------|
| 52. a. | fearnóg | <i>alder</i> | [farno:g] |
| b. | bord | <i>table</i> | [bord] |
| c. | banc | <i>bank</i> | [baNk] |
| d. | cursa | <i>course</i> | [kursÉ] |
| e. | calra | <i>calorie</i> | [kalrÉ] |

All consonants in Irish are subject to secondary articulation (either palatalization, velarization, or labialization¹⁶). In many cases, the secondary articulation is phonemic and must be present underlyingly. Furthermore, Irish requires that adjacent consonants (including those later separated by epenthesis) belong to the same consonant class with respect to secondary articulation. Interestingly, sharing a secondary articulation does not block epenthesis:

53. ainm *name* /anjm̥/ [anjEm̥]

This is an example of the binding discussed above in section 1. If we set the binding parameter for the feature [PLACE] we have an account of these facts.

54. Binding Parameter $\Phi = [\text{PLACE}]$

To see how this works let us take the word *calra* “calorie” /kalrÉ/. Possible brackettings are in (55)

55. a) [k a l] [r É]
 b) [k a][l r É]

Neither of these brackettings are acceptable. The /l/ can be bracketted with neither the first vowel, as in both cases the minimal distance between the [[l]] and the [[r]] is 0, which is less than the requisite |4|. Under normal circumstances the /l/ would take an epenthetic vowel after it, in order to break up the cluster which violates the minimal distancing constraint. However, in this case the /l/ share the Φ (place) node with the adjacent syllabified /r/:

- 56.
-

The /l/ is thus prosodically licensed by virtue of being bound to the /r/. This account has the advantage that it elegantly explains, why--leaving all questions about the crossing of association lines aside--the place node (and not sonorancy, voice, or continuancy) blocks epenthesis in Irish.

¹⁶See de Bhaldraithe (1947) and Ó Siadhail (1989) for a complete description of these facts

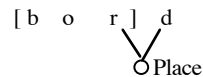
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Let us consider a different example: bord “table” [bord]. The following is the only bracketting which does not violate any constraints except minimal distancing.

57. [b o r | d]

This structure not satisfy the minimal distancing constraint: /r/ and /d/ are distant by only |3| steps on the sonority scale. The /d/ then must be licensed in some other manner. This is accomplished by the fact that it inherits its licencing from the already licensed /r/:

58.



3. Sonority and Irish minimal distancing

Up until this point, I have been assuming that the best way to characterize the sonority sequencing generalizations and the minimal distancing constraints is through the use of some sonority hierarchy. In this section, I will question this assumption. The examples which are most problematic are ones where there is an obstruent/obstruent cluster. Epenthesis does not apply when the first consonant in the cluster is an obstruent:

59. a. seacht “seven” [Saxt] *[SaxEt]
 b. bolgchaint “ventriloquism” [bolEgxajnt] *[bolEgExajnt]
 c. casmhair “concerned” [casvEr] *[casEvEr]
 d. antaiseipteach “antiseptic” [antESEptEx] *[antESepEtEx]

This is both surprising and problematic since the difference in sonority values in these clusters are all less than |4|, thus these clusters should violate the minimal distancing constraint.

60. a. [[x]] - [[t]], 3 - 1 = 2
 b. [[g]] - [[x]], 2 - 3 = -1
 c. [[s]] - [[v]], 3 - 4 = -1
 d. [[p]] - [[t]], 1 - 1 = 0

None of these clusters are licensed by any other condition (like binding by [place]), yet epenthesis does not apply here. This is clearly a fault with the system. We must therefore revise our system of sonority.

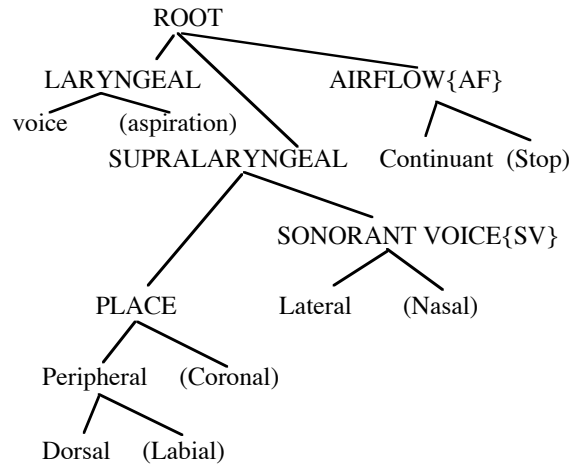
3.1 Rice (1992)

In this section, I will explore the theory of minimal distance and sonority developed in Rice (1992). After Clements (1990), she assumes that sonority is a derived notion. She derives the sonority hierarchy directly from the

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complexity of certain branches of the feature geometry. Using evidence from inventories and markedness, phonological and phonological processes Rice and Avery (1990, 1991) and Avery and Rice (1989), have developed the following geometry¹⁷ of features

61.



There are two types of nodes distinguished in this representation. There are the ORGANIZING nodes, indicated in upper case letters in the above diagram and there are the content nodes. The organizing nodes function to define sets of features that function alike. The content nodes represent the features that make up the constituent. These features are all monovalent (unary). Inherent in this representation is a system of markedness. “At each organizing node one of the dependents is universally unmarked, and as such is generally absent from underlying representation” (Rice 1992: 63). These unmarked nodes are represented in parantheses in the above representation. If a marked node is present in a features’ representation it must be present underlyingly. The major advantage to this system is its straightforward account of complexity. The more complex a segment is, the more features it has in its underlying representation. Rice’s claim that the more complex an element is along the sonority dimension (ie under the SONORITY VOICE (SV) node), the more sonorant it is¹⁸. This is seen in the following diagrams where all information other than SV and its dependents has been abstracted away:

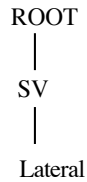
¹⁷I am using here the geometry used in Rice (1992) even though subsequent work by Rice and Avery has changed this model somewhat by placing the AIRFLOW node as a direct dependent of Supralaryngeal .

¹⁸This can be contrasted with Harris (1990) who claims that the less structure an element has the more sonorant it is. For arguments against Harris, I refer the reader to Rice (1993).

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62.

a. Liquid



b. Nasal



c. Obstruent

ROOT

(Rice 1992: 65)

With decreasing SV structure comes decreasing sonority. Rice posits that sonority can also be affected by structure under the AIRFLOW (AF) node, but this *need not* be the case. AF is necessary for computing sonority in languages like Greek and Korean (see Rice 1992 for more details), but is clearly unwanted in a language like Irish. This might be some parameterized notion. Notice that by allowing sonority to be computed on the basis of the SV node alone, we have dealt with the problem of the obstruent/obstruent clusters in Irish. Obstruents do not participate in sonority distancing because they don't have any SV structure. Take for example the /xt/ cluster in example (59a) repeated here as (63)

63. seacht “seven” [Saxt] *[SaxEt]

For this cluster, there is no constraint on the sonority distance between these two elements because neither of them have any relevant SV structure (here I am again abstracting away from all other structure¹⁹):

64. /x/ /t/
 ROOT ROOT

These examples have no SV node, thus do not participate in the minimal distancing constraint.

This is a nice result, in that we are now able to restrict the minimal distancing constraint to clusters that contain a sonorant (SV structure). However, we have now argued ourselves into a corner. We are unable to distinguish the sonority difference between a voiced stop and a voiceless one, thus it will not be able to account for the difference between a word like /bolg/ [bolEg] and one like /korp/ [korp]. This is because the difference between a voiced stop and a voiceless one is not defined under the SV node, but rather under the LARYNGEAL node. Apparently, we are at an impasse here. A sane person might throw up their hands in disgust and abandon the problem of Irish Epenthesis as being unsolvable. Being Irish Linguists, however, we shall

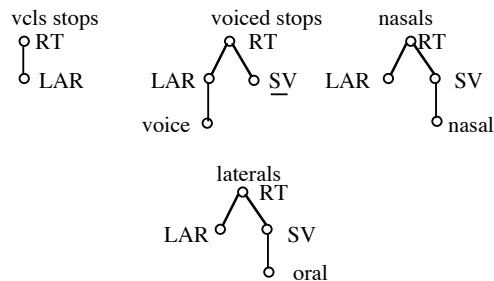
¹⁹The appropriate features distinguishing /x/ from /t/ all lie under the PLACE and AF organizing nodes so are not relevant to the sonority count.

attempt to see if there is a rational solution to the problem, without abandoning all the ground we have gained to this point. Fortunately, an alternative solution is available.

3.3 The Punchline on sonority

In this subsection, I will explore an alternative way of deriving sonority that also captures the obstruent/obstruent cluster problem. This approach will use the insight captured in Rice that sonority is an increase in feature structure, but differs from her in that minimal distancing constraints are phrased in terms of organizational nodes rather than SV structure. For the purposes of this section, I will assume the feature geometry given above in (61) with the sole distinguishing feature that I will not pay any attention to the SUPRALARYNGEAL node. This node is different from all other organizing nodes because it dominates no content nodes, for this reason I am leaving it out of the discussion. I will also be making the assumption that Irish is a “Class II” language in the sense of Avery and Rice (1989) and Rice (1993), in that it allows “sonorant obstruents”. These are voiced obstruents with an SV node. This obstruent SV node is “special” because it does not receive the unmarked interpretation of [nasal]. I will indicate such SV nodes by underlining them. Rice (1993) argues this structure for Irish on the basis of the facts of initial mutations. I will not repeat the arguments here and I refer the reader to the original paper. A class II language has the following feature contrasts:

65)



The analysis presented in this section will make crucial reference to two characteristics of Rice and Avery’s geometry: 1) the fact that there are organizing nodes, 2) the fact that organizing nodes can be present underlyingly with no dependents (ie they are interpreted with the unmarked feature). I will also claim that there is a difference in what “counts” as a relevant node depending upon the structural position in which the segment stands.

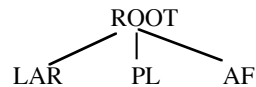
The basic claim of this analysis is that some nodes “count” for minimal distancing requirements and some don’t. I claim that nodes that “count” are only those with dependent structure. This is defined in (66)

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66. In a feature geometry F, organizational node N will count as a *specified node* iff it has any underlying dependent structure.

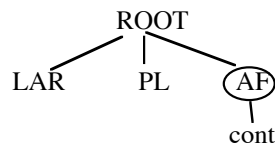
Consider the following diagram for the segment /t/. This would be the underlying representation of the segment. It is the most unmarked consonant. None of the organizational nodes have dependents:

- 67.



Thus none of its nodes are “specified”. Contrast this with the geometry for the segment /s/:

- 68.

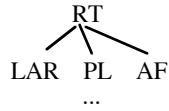


This node has a specified Airflow node, since the dependent feature [continuant] is marked and must be present underlyingly. I will mark specified nodes with a circle in all diagrams. The following diagrams show the “specified” features for all the major manner classes. I am assuming here that “liquids” don’t have any AF node.

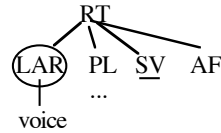
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69.

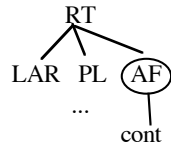
a. Voiceless stops



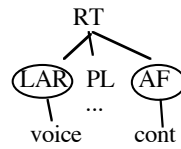
b. Voiced Stops



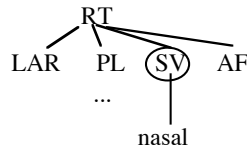
c. Voiceless Fricative



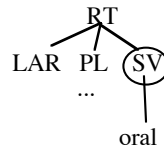
d. Voiced Fricatives



e. Nasal Stops



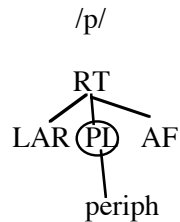
f. Liquids



Voiceless stops have no specified nodes, voiced stops, voiceless fricatives, liquids and nasals all have one, and voiced fricatives have two.

So far I have made no mention of the specificity of the PLACE node. Presumably, in all non-coronal elements, the place node is specified:

70.



The PLACE node is not, however, relevant in determining sonority distinctions (although it is relevant to binding). This brings us to a second notion: that of NODE RELEVANCE. A node is “relevant” when it is specified, and a particular mechanism in the grammar makes specific reference to it. I will claim that the relevance of a node is determined by the labelling of the segment that dominates it. This will eventually derive the fact that the C^x element in a cluster which

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undergoes epenthesis must be sonorant. I will claim that the notion of node relevance is a parameterized notion. I suggest the following parameters.

71. ρ_α (nodes relevant for C^{x+1}) = (All manner features/SV)
 ρ_β (nodes relevant for C^x) = (All manner features/SV)
 ρ_ϕ (Binding Relevance²⁰) = (PLACE/ROOT)

I will now revise the minimal distancing constraint to incorporate these notions. This revision will not account for obstruent/obstruent clusters:

72. *Minimal Distance Constraint* (parameter)
 a) on/off (unmarked: ON)
 b) Right of nucleus/Left of Nucleus
 c) $\delta = 1$ or 0 (unmarked = 0)
 $*|\rho_\beta| - |\rho_\alpha| < \delta$

The symbols $|\rho_\alpha|$ etc. should be read as “the number of relevant specified nodes as defined by the parameter ρ_α ”. This definition is similar to that given above in section 1, but it defines the notion of sonority value with a notion of counting relevant specified nodes. We must also revise our notion of sonority sequencing. Sonority sequencing does not seem to be affected by any particular relevant node, only specified ones. These revisions are shown in (73):

73. *Sequencing Constraint* (Universal)
 $*[[C^x]] - [[C^{x+1}]] < 0$
 where $[[Y]]$ is the number of specified nodes under Y

Let us now see how this works for Irish. In advance let's set the parameters for Irish as follows:

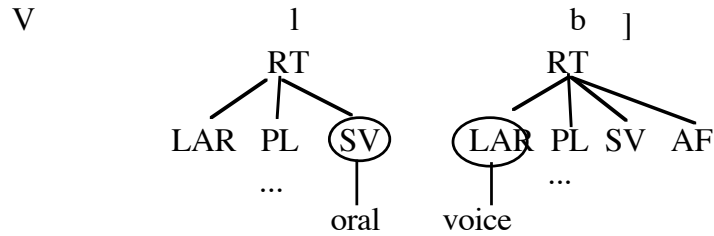
74. Sequencing (Universal)
 Syllable Head (Universal)
 Onset (Universal)
 Prosodic Licensing = On
 Binding = On
 $\rho_\phi = \text{PLACE}$
 Minimal Distance = On
 -Direction: Right of Nucleus
 - $\delta = 1$
 - $\rho_\alpha ([[C^{x+1}]]) = \text{All manner features (LAR, AF, SV)}$
 - $\rho_\beta ([[C^x]]) = \text{SV}$
 Coda = Off
 Anti-homorganicity = Off

²⁰Replaces the binding parameter given in section 3.2

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Consider a case where epenthesis would apply: a word final /lb/ cluster (like that found in *bolb* /bolb/ [bolEb]). (155) shows the only possible syllable structure for this form and shows the relevant underlying feature geometry:

75.



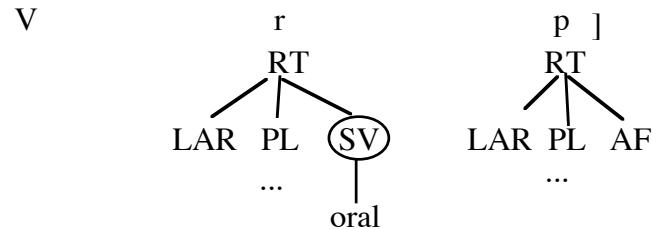
The number of relevant nodes for the C^x is 1; the number for C^{x+1} is 1. :

76.
$$\frac{|\rho_\beta| - |\rho_\alpha|}{1 - 1} = 0$$

 $0 < 1$ therefore does not meet the minimal distance constraint

Since there the minimal distancing constraint is violated, epenthesis must apply to correct the representation. Let us now contrast this example with one where epenthesis does not apply. Consider an example with an /rp/ cluster (like *corp* /korp/ [korp]):

77.



Counting the number of relevant specified nodes we get the following result:

78.
$$\frac{|\rho_\beta| - |\rho_\alpha|}{1 - 0} = 1$$

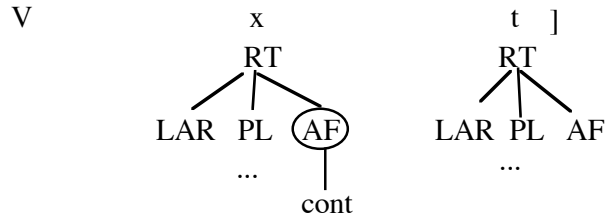
 $1 = 1$ therefore MD is met

Minimal distancing is met in this cluster, so no epenthesis applies. Deriving sonority from the number of major class nodes we now have an account of the basic facts of Irish epenthesis.

Whence Sonority

We must return now to the problem of obstruent/obstruent clusters. Notice that in all the cases of obstruent/obstruent clusters cited, the element in the governed position completely LACKS the relevant SV node. This is the insight of Rice (1992), when the SV node is not present, the minimal distancing constraints don't hold, but the sonority sequencing generalization does. Let us consider the word *ceacht* /kʲaxt/. The following diagram shows the structure of this coda:

79.



In this structure, the /x/ has one specified node: AF. This node is not the ρ_β for Irish. The ρ_β for Irish is SV. The /x/ does not contain an SV node thus it meets the minimal distancing requirement and epenthesis does not apply.

4 Conclusion

In this paper, I have shown how sonority may be derived directly from the markedness relations in the feature geometry. In so doing, I also outlined a system of parameterized constraints on syllabic constituency that can be used to describe structural relations between segments. While this paper focussed on Irish syllabification, I hope that the constraints and the system of sonority evaluation developed here will lead to research into sonority relations in other languages.

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