The perceptual dimensions of sonority-driven epenthesis

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Abstract

Vowel epenthesis often appears to preferentially target consonant clusters with rising sonority. One explanation for this is perceptual faithfulness (Fleischhacker, 2002; Steriade, 2006): rising sonority clusters are more susceptible to epenthesis because the perceptual distance between the underlying /C_1C_2/ sequence and its correspondent output sequence [C_1VC_2] is small, thus incurring a smaller faithfulness cost. This raises the question of how to compute the perceptual distance between two sonority contours /C_1C_2/ and [C_1VC_2] in terms of the sonority of C_1, C_2 and V. In this paper, I propose that the appropriate metric is SONORITY ANGLE, the angle formed by the contours C_1C_2 and C_1V, and apply it in analyzing two case studies of sonority-driven epenthesis, Chaha and Irish. A comparison is made to another possible metric, SONORITY RISE (Flemming, 2008), the ratio of the gradients of the two contours, as well as to Syllable Contact, which represents an alternative, markedness-based approach to the problem of sonority-driven epenthesis.

Contents

1 Introduction

Vowel epenthesis often appears to preferentially target consonant clusters with rising sonority. There are two broad classes of explanation within Optimality Theory for such sonority-driven epenthesis.

One is faithfulness-based: the perceptual distance between the underlying /C_1C_2/ sequence and its correspondent output sequence [C_1VC_2] is small when the cluster is of rising sonority. Thus, epenthesis into such a sequence incurs a smaller faithfulness cost than epenthesis into a cluster of falling sonority. This is the basis of the analysis proposed by Fleischhacker (2002, 2005) to explain why rising sonority obstruent-sonorant clusters are more easily epenthesised in to than falling sonority sibilant-stop clusters.

This faithfulness-based approach raises the question of how the perceptual distance between two sonority contours /C_1C_2/ and [C_1VC_2] should be computed in terms of the sonority of C_1, C_2 and V. Fleischhacker's analysis rested on empirical determinations of sonority contour faithfulness, and did not attempt to determine such a relation.

Steriade (2006) proposed that input and output sonority contours should match in terms of whether they are rising or falling, and to what degree, but did not suggest a concrete mathematical relation. Flemming (2008) formalises Steriade's approach with the metric SONORITY RISE, the ratio of the gradients of the two contours.

In this paper, I suggest an alternative metric, SONORITY ANGLE, namely the magnitude of the angle made by the vectors C_1-C_2 and C_1-V, and explore the ramifications of this choice.

SONORITY ANGLE makes the same broad predictions as SONORITY RISE – that clusters of rising sonority, having a relatively small angle between the underlying sonority contour /C_1-C_2/ and the overt sonority contour [C_1-V], are perceptually more similar to their epenthetic output, and therefore more likely to undergo epenthesis, than clusters of falling sonority. Crucially, however, the exact hierarchy of susceptibility of individual clusters to epenthesis is predicted to be different.

I take two instances where the predictions of SONORITY ANGLE and SONORITY RISE differ and illustrate with case studies of sonority-driven epenthesis in two different languages, namely Chaha and Irish, that the predictions of SONORITY ANGLE are more in line with the data than those of SONORITY RISE.

The other broad class of explanation for sonority-driven epenthesis is markedness-based. Syllable Contact (Murray & Vennemann, 1983) holds that across a syllable boundary, falling sonority clusters are more harmonic than rising sonority ones. Hence, rising sonority clusters are preferentially broken up by epenthesis.

Syllable Contact forms the basis for the main existing analysis of Chaha epenthesis by Rose (2000). I show that the faithfulness-based analysis, powered by the metric of SONORITY ANGLE, is more economical. In the case of Irish, Syllable Contact makes incorrect predictions regarding the data.

The layout of this paper is as follows. Section 2 lays out the theoretical background for the sonority contour faithfulness approach to sonority-driven epenthesis. I introduce the proposed SONORITY ANGLE metric as well as the competing SONORITY RISE metric (Flemming, 2008), then lay out the alternative markedness-based approach to sonority-driven epenthesis, namely SYLLABLE CONTACT.

Section 3 consists of a case study of sonority-driven epenthesis in Irish. I show that the data are in line with the predictions of SONORITY ANGLE and not SONORITY RISE, while a Syllable Contact-based analysis would have to be very complicated to explain the same facts.

Section 4 is a case study of epenthesis positioning in Chaha. I detail the facts of epenthesis positioning in Chaha, based on the data given in Rose (2000), and show that the sonority contour faithfulness approach explains these facts, with SONORITY ANGLE as the metric for comparing sonority contours. I compare it to SONORITY RISE and show that the former is the more successful analysis, and that overall, the approach just outlined is more economical than the Syllable Contact-based approach of Rose (2000).

Section 5 looks at various issues regarding SONORITY ANGLE, such as its robustness. Section 6 concludes.

2 Theoretical background

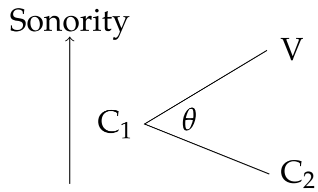
This paper assumes as its basis the P-map hypothesis (Steriade, 2001), which states that the perceptual distance between underlying representations and potential surface forms projects a fixed ranking of faithfulness constraints.

In order to determine what faithfulness constraints exist in CON and what their rankings should be, therefore, we need to know the metrics of perceptual distance that are relevant to each change. In the case of vowel epenthesis, the perceptual distance to be measured is between two sonority contours, /C1-C2/ and [C_1-V-C_2].

2.1 Sonority Angle

The observation with which we started was that the more steeply rising the sonority profile of a consonant cluster, the more likely the cluster to undergo epenthesis. Thus the absolute difference in sonority between C_1 and C_2 must be factored into the metric. To this, I add the claim that the more sonorous C_1, the more likely the cluster is to undergo epenthesis.

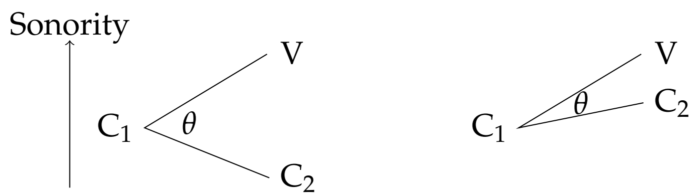
These two factors are neatly captured by the metric SONORITY ANGLE, which is defined as the angle between the underlying C_1C_2 sonority contour and the surface C_1V contour:

(1) 

Assuming that the horizontal distance is 1 unit, we can compute the magnitude of this angle analytically with the following formula:

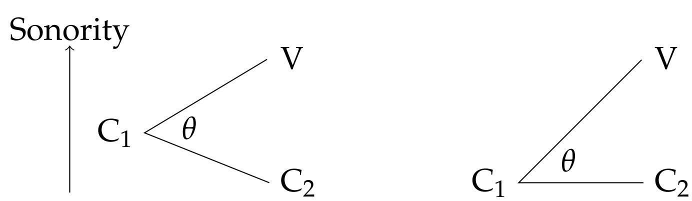
(2) Formula: SONANGLE = $arctan(V - C_1) - arctan(C_2 - C_1)$

Let us verify that SONORITY ANGLE does indeed reflect the two generalisations we wish to make: first, that the smaller the sonority distance between C_1 and C_2, the smaller the sonority angle. Imagine fixing C_1 as in (1) and raising the sonority of C_2. Intuitively, this decreases the SONORITY ANGLE, comparing the two below.

(3) 

The dependence of SONORITY ANGLE on this distance can also be seen in the second term in (2).

The second generalisation is that the more sonorous the C_1, the more likely epenthesis is to occur. This time, fix C_2 and lower the sonority of C_1.

(4) 

While the difference is less clear visually, the second angle is larger. The first term in the formula confirms the relation between the sonority of C_1 in terms of its closeness to V, and SONORITY ANGLE as a whole.

Given a sonority scale where classes of consonants are mapped to a numerical sonority, we can now calculate the SONORITY ANGLE for any cluster, which can be thought of as the faithfulness cost of epenthesising between the two consonants. Examples of the calculation are given below.

In this paper, I adopt (with, later, minor modifications) the following standard scale:

(5)

T	F	N	R	G	V
stop	fricative	nasal	liquid	glide	vowel
1	2	3	4	5	6

The SONORITY ANGLES for NT, TT and TN are calculated as in the following examples.

(6) a. SONANGLE(NT) = $arctan(6-3) - arctan(1-3) = 2.35$
b. SONANGLE(TT) = $arctan(6-1) - arctan(1-1) = 1.37$
c. SONANGLE(TN) = $arctan(6-1) - arctan(3-1) = 0.27$

The larger the SONORITY ANGLE, the larger the faithfulness cost. We therefore expect it to be hardest to epenthesise into NT out of these three clusters, and easiest to epenthesise into TN.

We formalise the idea of the faithfulness cost by defining a family of IDENT constraints that penalise outputs that incur faithfulness costs of greater than a certain n.

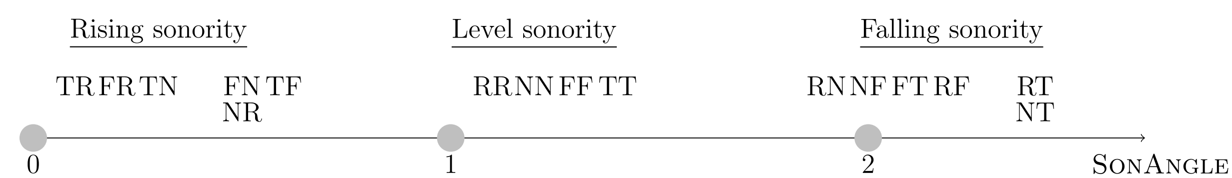
(7) IDENT(SONANGLE)$< n$: Assign a violation mark if the consonants in two strings C_1C_2 and C_1VC_2 stand in correspondence, and the sonority angle between C_1C_2 and C_1V is greater than n.

These faithfulness constraints have a universal ranking, with the least stringent the highest-ranked.

(8) ...
$\gg$ IDENT(SONANGLE)<1.5
$\gg$ IDENT(SONANGLE)<1.0
$\gg$ IDENT(SONANGLE)<0.5
$\gg$ ...

The resulting hierarchy of clusters, ranked according to their resistance to epenthesis as defined by their SONORITY ANGLE, is as follows.

(9) SONORITY ANGLE hierarchy



Notice that out of the falling sonority clusters, those that decrease in sonority by a single step – namely RN, NF and FT – have smaller SONORITY ANGLES than the ones that have a greater fall in sonority. Furthermore, out of these three clusters, theone with the most sonorous C_1, RN, has the smallest SONORITY ANGLE. We thus predict that out of the falling sonority clusters, RN is the most likely to be broken up by epenthesis. The case study on Chaha will demonstrate that this is the case.

Similarly, between the clusters that fall in sonority by two steps – RF and NT – we expect NT to be less likely to undergo epenthesis, since N is less sonorous than R. We expect NT and RT to be the clusters most resistant to epenthesis out of all the clusters. This will be crucial to our analysis of Irish sonority-driven epenthesis.

2.2 Sonority Rise

I will contrast SONORITY ANGLE with an alternative metric of sonority contour faithfulness proposed by Flemming (2008), SONORITY RISE, which takes the ratio of the underlying sonority contour /C_1C_2/ and the surface contour [C_1V].

(10) SONORITY RISE = $1 - \frac{C_2 - C_1}{V - C_1}$

The following sample calculations illustrate how SONRISE distance is computed:

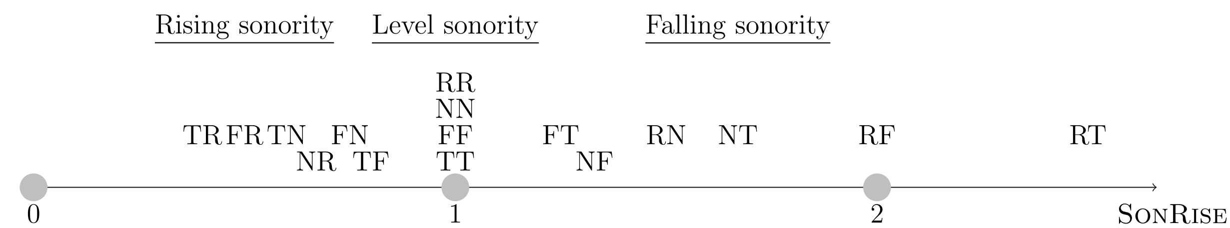
(11)

C_1C_2	Rise	C_1V	Rise	SONRISE Distance
NT	-2	NɨT	3	$1 - \frac{1-3}{6-3} = 1.7$
TT	0	TɨT	5	$1 - \frac{1-1}{6-1} = 1.0$
TN	2	TɨN	5	$1 - \frac{3-1}{6-1} = 0.6$

As with SONORITY ANGLE, this gives rise to a family of constraints IDENT(SONRISE)$< n$, defined similarly to IDENT(SONANGLE)$< n$.

SONORITY RISE also gives rise to a hierarchy of susceptbility of clusters.

(12) SONORITY RISE hierarchy



Though in many ways similar to the SONORITY ANGLE hierarchy, it makes several crucially different predictions. For example, it does not share the prediction of SONORITY ANGLE that RN is the most likely of the falling sonority clusters to epenthesise – rather, if RN undergoes epenthesis then we expect FT and NF to do the same. Furthermore, it predicts that if NT and RT fail to undergo epenthesis due to the high faithfulness cost of interrupting these clusters, then RF should also fail to undergo epenthesis. Both of these predictions are contrary to the evidence of Irish and Chaha.

2.3 Another dimension of sonority contour faithfulness

Note that I do not claim that sonority contour faithfulness is the only dimension of perceptual similarity relevant to vowel epenthesis. For instance, I will adopt Flemming (2008)'s suggestion that a further dimension of perceptual similarity restricts epenthesis to sites adjacent to a sonorant, based on patterns of epenthesis in languages such as Montana Salish, where epenthesis is disallowed between two obstruents.

I will formalise this restriction with the constraint DEP(+SONORANT). The epenthesis of a vowel between two obstruents, which bear the feature [−sonorant], necessitates the insertion of a new [+sonorant] feature, whereas when a vowel is epenthesised adjacent to a sonorant, the sonorant's [+sonorant] feature spreads and is shared between the vowel and the sonorant.

This constraint will be used in the analysis of Chaha complex coda epenthesis, which in some idiolects cannot occur between obstruents, while in others, it can. My proposal will be that in the former, DEP(+SONORANT) is higher-ranked, thus blocking epenthesis.

2.4 Syllable Contact

The alternative markedness-based approach to sonority-driven epenthesis that I will explore in this paper is Syllable Contact, which was first stated as the Syllable Contact Law by Murray & Vennemann (1983):

(13) "The preference for a syllabic structure *A*\$*B*, where *A* and *B* are marginal segments and *a* and *b* are the Consonantal Strength values of *A* and *B* respectively, increases with the value of *b* minus *a*" (Murray & Vennemann, 1983)

Rose (2000) reformulates this as a violable, but categorical, constraint within the context of Optimality Theory and uses it in an analysis of Chaha sonority-driven epenthesis:

(14) SYLLCON: The first segment of the onset of a syllable must be lower in sonority than the last segment in the immediately preceding syllable.

More recently, Syllable Contact has been recast as a gradient family of constraints, for example by Gouskova (2002, 2004). She defines the distance DIS between two consonants in a syllable contact situation as the sonority of the second minus the sonority of the first. For example, [t.s] = +1 if [s] and [t] are only one step apart on a sonority scale. She then defines the following family of constraints:

(15) *DIS-*n*: Assign a violation mark if the DIS between two adjacent heterosyllabic consonants is *n* (adapted from (Gouskova, 2002))

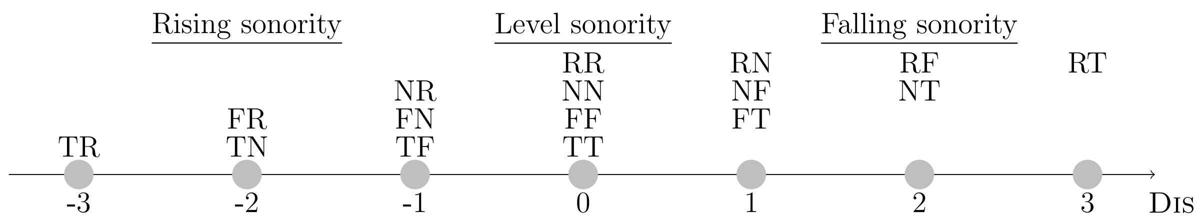
This gives rise to a universal hierarchy:

(16) *DIS+7 $\gg$ *DIS+6 $\gg$ ... *DIS+0 $\gg$ *DIS-1 $\gg$ ... *DIS-7.

Thus heterosyllabic clusters that rise sharply in sonority – that have a high DIS – are more marked than more falling clusters.

The predicted hierarchy of susceptibility to epenthesis of the clusters is as follows:

(17) Syllable Contact hierarchy (based on *DIS):



Syllable Contact applies only across syllable boundaries. Therefore, when sonority-driven epenthesis occurs in onsets or codas, other sonority-based markedness constraints must be employed. One such is SONORITY SEQUENCING (Selkirk, 1984), which states that sonority must be strictly increasing in the onset and strictly decreasing in the coda. (Rose, 2000) uses two variants of this constraint, one strict and one non-strict, in her analysis of Chaha.

3 Case study: Irish

Irish displays an unusual process of epenthesis that targets consonant clusters whose first member is a sonorant (Carnie, 1994; Ní Chiosáin, 1999), with the exception of sonorant-voiceless stop clusters, which never undergo epenthesis. I will show in this section that a SONORITY ANGLE-based faithfulness neatly captures these facts.

3.1 Data

Irish epenthesis targets sonorant-initial clusters and occurs both across syllable boundaries and in codas. The epenthetic vowel is [ə] in nonpalatalised environments and [i] otherwise (Ní Chiosáin, 1999).

(18) a. /albə/ → [aləbə]
Alba 'Scotland'

b. /dorxə/ → [dorəxə]
dorcha 'dark'

c. /gorm/ → [gorəm]
gorm 'blue'

d. /banbə/ → [banəbə]
Banba 'a name for Ireland'

e. /konfə/ → [konəfə]
confadh 'anger'

f. /an^{j}m^j/ → [an^{j}im^j]
ainm 'name'
(Carnie, 1994, (37)) and (Ní Chiosáin, 1999, (2))

The pattern of epenthesis outlined above does not apply to onset clusters. Sonorant-initial clusters are attested in onsets.

(19) a. [mnaː] or [mraː] (depending on dialect)
mná 'women'
b. [m^{j}r^{j}iːraːn]
mriathán 'sea-rods'
(Swingle, 1992, 456)

There are two classes of exceptions to this process. First, homorganic clusters are not broken up by epenthesis.

(20) a. /farnoːg/ → [farnoːg], *[farənoːg]
fearnog 'alder'
b. /bord/ → [bord], *[borəd]
bord 'table'
c. /kalrə/ → [kalrə], *[kalərə]
calra 'calorie'
(Carnie, 1994, (52))[1]

Second, epenthesis does not apply when the second consonant is a voiceless stop.

(21) a. /kork/ → [kork], *[korək]
Cork 'Cork (place name)'
b. /korkə/ → [korkə], *[korəkə]
corca 'people'
c. /korp/ → [korp], *[korəp]
corp 'body'
(Carnie, 1994, (39a,b,c))

3.2 Analysis

The fact that this process of epenthesis does not target obstruent-initial clusters is not problematic under the sonority contour faithfulness approach, as the IDENT(SONANGLE) constraints limit epenthesis, rather than trigger it. By choosing a more limited markedness constraint such as *SON-C, defined below, we can have epenthesis act only on sonorant-initial clusters.

[1] Ní Chiosáin (1999) has a more complicated set of facts as to which homorganic clusters are broken up by epenthesis. As this is not the focus of this paper, I will assume the simpler dataset that Carnie presents.

(22) *SON-C: Assign a violation mark for every sonorant consonant preceding another consonant.

(23) *SON-C ≫ DEP

Input: /gorm/	*SON-C	DEP
a. ☞ gorəm		*
b. gorm	*!	

Epenthesis does not break up onset sonorant-initial clusters. This is likely due to the fact that with a small number of lexical exceptions, Irish words are stress-initial (Ó Siadhail, 1989, 26).[2] Breaking up the onset cluster would result in an unstressable epenthetic vowel occupying the preferred location of stress in Irish.

I will assume initial stress is due to the following constraint, which is dominated only by lexicon-specific constraints.

(24) STRESS-INITIAL: Assign a violation mark if the initial syllable of a word is not stressed.

Alderete (2000) proposes a general constraint HEAD-DEPENDENCE against making an epenthetic segment a prosodic head, which I adopt and state informally here:

(25) HEAD-DEP: Assign a violation mark for every stressed vowel not present in the input.

Together, these two constraints ranking above *SON-C predict that onset epenthesis does not occur.

(26) STRESS-INITIAL, HEAD-DEP ≫ *SON-C

Input: /mnaː/	STRESS-INITIAL	HEAD-DEP	*SON-C
a. ☞ ˈmnaː			*
b. ˈmə.naː		*!	
c. mə.ˈnaː	*!		

In codas and across syllable boundaries, epenthesis does not apply to homorganic clusters. I suggest that this is due to the action of the Obligatory Contour Principle (OCP). I adopt Walter 2007's formulation of the OCP, which bans successive identical oral gestures. A cluster such as [nt] would consist of a single oral constriction gesture at the alveolar ridge, and would not constitute a violation of the OCP. Splitting it by epenthesis to form [nət] would require a repeated identical constriction gesture, and therefore be a violation of the OCP.

[2]With the exception of Munster Irish, where stress is attracted to syllables containing a long vowel or diphthong (Green 1996), but where onset clusters still are not broken up by epenthesis. In this case, one would probably have to posit a positional faithfulness constraint protecting the word-initial cluster.

(27) OCP ≫ *Son-C

Input: /bord/		OCP	*Son-C
a.	☞ bord		*
b.	borəd	*!	

Lastly, we come to the sonority-driven aspect of the analysis. Epenthesis is allowed when C1 is "followed by a voiced stop, fricative, nasal or liquid, but not when it is followed by a voiceless stop." (Carnie, 1994)

This requires a revision to the standard sonority scale, splitting up voiceless and voiced stops:

	Voiceless stop	Voiced stop	Fricative	Nasal	Liquid	Glide	Vowel
(28)	T	D	F	N	R	G	V
	1	1.5	2	3	4	5	6

Now let us calculate the sonority angles for the relevant set of sonorant-initial clusters in Irish.

(29) Sonority Angles of sonorant-initial clusters using revised sonority scale

The sonorant-voiceless stop clusters can be neatly separated from the rest of the clusters in terms of Sonority Angle. The correct constraint ranking is therefore the following:

(30) Ident(SonAngle)<2.3 ≫ *Son-C ≫ Ident(SonAngle)<2.4

Input: /kork/		Ident(SonAngle)<2.3	*Son-C	Ident(SonAngle)<2.4
a.	☞ kork		*	
b.	korək	2.35 *!		2.35 *

Input: /albə/		Ident(SonAngle)<2.3	*Son-C	Ident(SonAngle)<2.4
c.	☞ aləbə	2.29		2.29
d.	albə		*!	

A note on the nasal-voiceless stop clusters is in order here: such clusters tend to be homorganic on the surface. It is therefore unclear whether such clusters failed to be broken up by epenthesis because of OCP, or because of the large sonority contour faithfulness violation. I argue that in general, it is for the second reason.

Suppose nasal-voiceless stop clusters were banned from epenthesising because of the OCP. Then we would expect to see surface sequences of [NVP] where N and P have different places of articulation and V is an epenthetic vowel, just as we see [NVB] sequences:

(31) a. [bʲinʲib]
binb 'venom'
b. [banəbə]
Banba 'Banba (a name for Ireland)'
(Carnie, 1994, 2c)

To my knowledge, no [NVP] sequences with the properties stated above exist.

Further, albeit marginal, evidence comes from the existence of words with heterorganic [NP] sequences, which are not broken up by epenthesis.

(32) a. [sʲeːmt]
séimt 'the act of playing music', dialectal variant of *seinm*)
b. [kʌrʲəmʲkʲ]
cuirimc 'I observe, pay attention to' (Connaught dialect)
(Words found in **?**)

I conclude that in general, epenthesis does not occur in /NT/ sequences due to the large sonority angle between NT and NVT, and not to the non-existence of underlying heterorganic /NP/ clusters in the lexicon.

4 Case study: Chaha

5 Issues

6 Conclusion

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