# 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.

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# 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 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. Similarly to 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 major 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

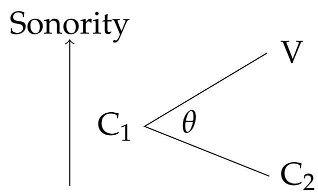
This paper assumes as its basis the P-map hypothesis Steriade (2001), which states that the perceptual distance between underlying representations and potential surface forms projects a fixed ranking of faithfulness constraints.

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:

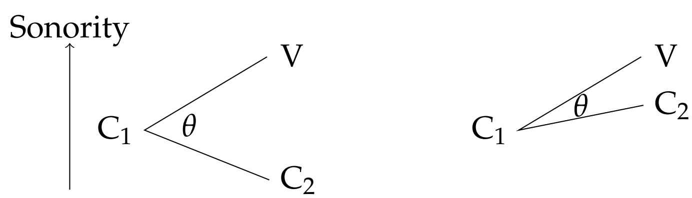



(1)

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

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

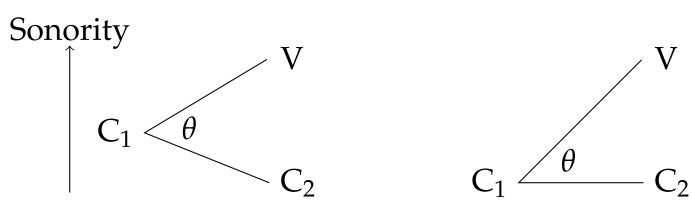
Let us verify that SONORITY ANGLE does indeed reflect the two generalisations we wish to make: first, that the smaller the sonority distance between $C_1$ and $C_2$, the smaller the sonority angle. Imagine fixing $C_1$ as in (1) and raising the sonority of $C_2$. Intuitively, this decreases the SONORITY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

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

The SONORITY ANGLES for NT, TT and TN are calculated as follows.

(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 $n$.

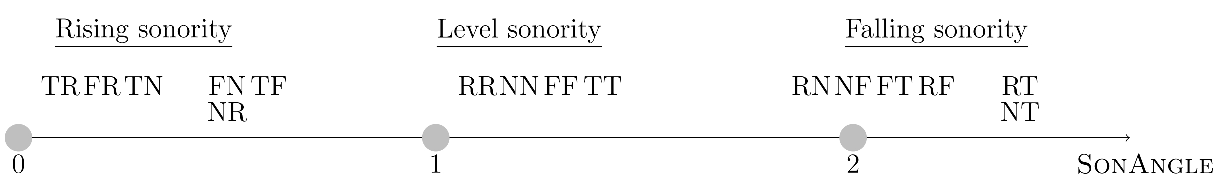
(7) IDENT(SONANGLE)$< n$: Assign a violation mark if the consonants in two strings $C_1C_2$ and $C_1VC_2$ stand in correspondence, and the sonority angle between $C_1C_2$ and $C_1V$ is greater than $n$.

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 [$C_1$V].

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

The following sample calculations illustrate how SONRISE distance is computed:

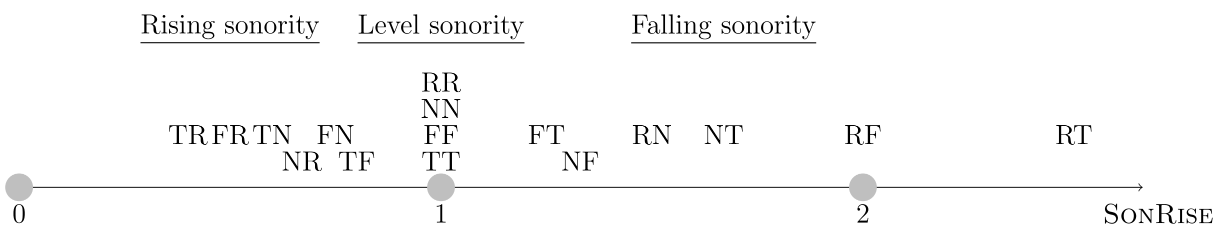
(11)

| $C_1C_2$ | Rise | $C_1$V | 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.

## 2.3 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):

| | Rising sonority | | Level sonority | | Falling sonority | |
|---|---|---|---|---|---|---|
| | | | RR | RN | RF | RT |
| | | NR | NN | NF | NT | |
| | FR | FN | FF | FT | | |
| TR | TN | TF | TT | | | |
| -3 | -2 | -1 | 0 | 1 | 2 | 3 |

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. Once such is Sonority Sequencing, which we will see in the context of Rose’s analysis in the next section.

### 2.4 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 epenthesis. As we will see later in the paper, other faithfulness constraints may prevent epenthesis, such as a restriction on epenthesising a vowel between two obstruents, which introduces an additional region of sonorance that had previously not existed (Flemming, 2008).

## 3 Case study: Irish

## 4 Case study: Chaha

## 5 Issues

## 6 Conclusion

## References

Fleischhacker, Heidi. 2002. Cluster-dependent epenthesis asymmetries. In *UCLA Papers in Phonology 5*, .

Flemming, Edward. 2008. Asymmetries between assimilation and epenthesis. MIT ms.

Gouskova, Maria. 2002. Exceptions to sonority distance generalizations. In *CLS 38*, .

Gouskova, Maria. 2004. Relational hierarchies in ot: the case of syllable contact. *Phonology* 21(2). 201–250.

Murray, Robert W. & Theo Vennemann. 1983. Sound change and syllable structure in Germanic phonology. *Language* 59. 514–528.

Rose, Sharon. 2000. Epenthesis positioning and syllable contact in chaha. *Phonology* 17. 397–425.

Steriade, Donca. 2001. The Phonology of Perceptibility Effects: the P-map and its consequences for constraint organization. MIT ms.

Steriade, Donca. 2006. Contour correspondence: evidence from cluster interruption. Handout, OCP3.