PHONOLOGY WITH TERNARY SCALES

A Dissertation Presented

by

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> The heavens declare the glory of God; and the firmament sheweth his handiwork. Day unto day uttereth speech, and night unto night sheweth knowledge. There is no speech nor language where their voice is not heard. Their line is gone out through all the earth, and their words to the end of the world. *Psalm 19:1–4*

ABSTRACT

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This work proposes a series of ternary scales which make certain phonological distinctions traditionally made with binary or privative features. The dissertation focuses on the Inherent Voicing scale, which has the values Voiceless Obstruent, Voiced Obstruent, and Sonorant. This scale replaces the traditional features [voice] and [sonorant]. Other scales proposed are the Consonantal Stricture scale (stop, fricative, approximant/vocoid) and the Vowel Height scale (low, mid, high), which replace [continuant], [consonantal], [high] and [low].

Applied within Optimality Theory, the ternary scales framework provides natural explanations for a number of phonological processes which are opaque in binary models. A ternary scale groups together certain phonological classes, while also making a statement that some values on the scale are closer to each other than others. Specifically, some values are adjacent on the scale and others not. This statement is impossible to make in binary features, but is necessary to capturing certain phonological phenomena. Once assimilation constraints and faithfulness constraints are allowed to make reference to the order and adjacency of the scale values, a natural explanation emerges for previously puzzling processes, such as chain shifts, attraction (as when voiceless obstruents voice before sonorants, or low vowels become mid before high vowels) and coalescence (as when low vowels and high vowels coalesce to mid). Other, more

apparently binary processes (such as voicing assimilation or neutralization in obstruents) are also analyzed on the ternary scale. Such processes are part of a larger class of phenomena which call for a ternary analysis.

Chapter 2 considers assimilation and attraction on the Inherent Voicing scale, showing that voicing assimilations in obstruents are a subset of assimilations occurring on the full ternary scale. Chapter 3 analyzes chain shifts (where voiceless obstruents voice and voiced obstruents become sonorants) as one-step movements along the ternary scale, caused by faithfulness constraints which require that the output stay near the input. Chapter 4 examines the effects of the markedness of voiced obstruents (including coda neutralization) in the context of the Inherent Voicing Scale. Chapter 5 turns to the Consonantal Stricture Scale and Vowel Height Scale, applying analyses developed in earlier chapters.

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CHAPTER 1

INTRODUCTION TO TERNARY SCALES

Gallia est omnis divisa in partes tres…
Caii Julii Caesaris, *Comentarii de Bello Gallico*

1.1 Ternary Scales Defined

The main question that this dissertation seeks to answer is why voiced obstruents sometimes act with sonorants, sometimes with voiceless obstruents, sometimes alone, and sometimes with *both* voiceless obstruents and sonorants in a single process. For instance, in a number of languages (such as Hungarian, discussed in Chapter 2.1.1) coda voiceless obstruents voice before onset voiced obstruents, while remaining voiceless before onset sonorants. In other languages (such as Krakow Polish, see Chapter 2.6) voiceless obstruents voice before an onset voiced obstruent *or* sonorant. On the other hand, in Irish a voiceless obstruent becomes a voiced obstruent, while a voiceless obstruent becomes a sonorant. So in Hungarian the voiced obstruents act alone in causing voicing, while in Krakow Polish they pattern with the sonorants, and in Irish all three are caught up in a single chain shift. What is the true relationship amongst voiced obstruents and voiceless obstruents and sonorants?

The answer that I present here is that voiced obstruents are the middle value of a ternary scale. Voiced obstruents are next to voiceless obstruents on the one side, and sonorants on the other side of the scale. The scale moves from voiceless at one end, through non-inherent voicing, to inherent (spontaneous) voicing at the other end. The Inherent Voicing scale is shown in (1).

(1) Proposed Inherent Voicing Scale

voiceless obstruent,	voiced obstruent,	sonorant = the Inherent Voicing Scale
1	2	3

Similar questions can be asked about fricatives and mid vowels: Why do fricatives sometimes act with approximants and vocoids, sometimes with stops, sometimes alone, and sometimes with both as the middle step of a chain shift? And why do mid vowels sometimes act with high vowels, sometimes with low vowels, sometimes alone, and sometimes with both in a chain shift? Fricatives and mid vowels are also middle values on ternary scales, as shown in (2).

(2) Other proposed Ternary Scales

stop, fricative/liquid, vocoid/laryngeal = the Consonantal Stricture Scale.
1 2 3

HIGH, MID, LOW = the Vowel Height Scale[1]

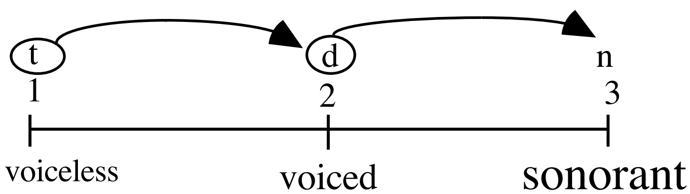
The scales in (1) and (2) replace the binary or privative features [voice], [sonorant], [continuant], [consonantal], [high] and [low]. This means that many phonological distinctions previously made with binary features (Jakobson, Fant & Halle 1967, Chomsky & Halle 1968 (SPE)) are actually ternary and scalar. The structure of the scales is such that any two adjacent values on a scale form a natural class as opposed to the third value. Thus values 1 and 2 on the Inherent Voicing (IV) scale are obstruents, while value 3 is sonorant. Values 2 and 3 on the IV scale are voiced, while value 1 is unvoiced. Similarly for the Consonantal Stricture (CS) scale, values 1 and 2 are consonantal while value 3 is not, and values 2 and 3 are continuant while value 1 is not. On the Vowel Height (VH) scale, high vowels are classed apart from mid and low, while low vowels are classed apart from mid and high.

Evidence from a variety of phonological phenomena points to the need for these ternary scales. I will briefly outline the evidence here before taking up the individual points more thoroughly in the succeeding chapters. The first type of evidence comes from chain shifting assimilations and consonant mutations. In

[1] See Chapter 5.4 for a discussion of numerical values on the Vowel Height Scale.

the Irish nasalizing mutation, for example, voiceless obstruents become voiced and voiced obstruents become nasal sonorants in certain morphosyntactic environments (Ní Chiosáin 1991). Chain shifts like nasalization in Irish suggest that a voiced obstruent is to a voiceless obstruent as a sonorant is to a voiced obstruent. The IV scale represents this by having voiced obstruents adjacent to voiceless obstruents and sonorants adjacent to voiced obstruents. Under the influence of an IV3 (sonorant) segment, the Irish consonants move one step up the IV scale, as described in detail in Chapter 3, and shown schematically in (3).

(3) Chain shift on the IV scale

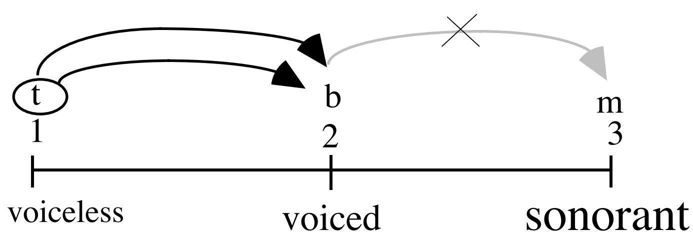


The chain shift in (3) can be represented on the IV scale as a natural process. By contrast, SPE-type binary features fail to capture such chain shifts. That failure has been well documented by Foley (1970 et seq.). In a binary-feature framework the two halves of the chain shift (voiceless → voiced and voiced → sonorant) can not be captured as a single natural process. In the rule-based system of SPE, a switch from [–voice] to [+voice] and a switch from [–sonorant] to [+sonorant] are simply not related. An autosegmental approach (such as Massam 1983), which has the mutating segment take on either of a pair of floating features [voice] and [sonorant], must still stipulate that the two features [voice] and [sonorant] must occur together while most other feature combinations do not. The ternary scales framework makes explicit the relationship between [voice] and [sonorant] by placing them on a scale.

Similar arguments can be made in the case of Consonantal Stricture. Leniting consonant mutations, such as that in Irish, have the general form stop → fricative, fricative → *h*. This suggests that a fricative is to a stop as *h* (or a vocoid) is to a fricative. In the ternary scales model fricatives are adjacent to stops and glides and laryngeals are adjacent to fricatives. Chain shifting assimilations of vowel height, low → mid → high also suggest that mid is to low as high is to mid.

Another point of evidence for the ternary scales is that of attraction. In a language such as Krakow Polish, coda voiceless obstruents become voiced both before voiced obstruents and before sonorants. The implication is that voicing an obstruent before a sonorant is an assimilatory process, i.e. the obstruent becomes closer to the sonorant. The attraction is shown schematically in (4).

(4) Attraction toward sonorants on the IV scale



As the picture in (4) shows, movement to a voiced obstruent brings a voiceless obstruent closer to a sonorant in cases where full assimilation to the sonorant is ruled out (as shown by the 'x'). In binary features, such processes can be captured by simply assimilating to the feature [+voice]. A quantity of evidence has emerged, however, to show that sonorants and obstruents do not have the same type of voicing, and so should not be subsumed under a single [+voice] feature. Sonorants often do not interact with obstruents at all. In approaches such as Itô & Mester (1986) and Lombardi (1991), sonorants are unspecified for [voice]. Any voicing effect of sonorants on obstruents must occur after a default fill-in of [voice] near the end of the phonological derivation. Thus for Itô, Mester and Lombardi, sonorants have two different specifications for [voice], depending on the point in the derivation. In approaches such as Rice & Avery (1989) and Rice (1993), sonorants are recognized as having a different kind of voicing than voiced obstruents. Sonorants have an SV (Sonorant Voice) node, while obstruents have [voice] under the Laryngeal Node.[2] This separation of voicing types accounts for the non-interaction of sonorants and obstruents. However when sonorants do cause voicing in obstruents the obstruents must be given an SV node. Thus there are two representations of voiced obstruents for Rice and Avery.

The ternary scales framework avoids the need for underspecification and default fill-in[3] by using the insight of Rice & Avery (1989) and Rice (1993) that voicing in sonorants is phonologically different from the voicing in obstruents. Sonorants are inherently voiced (IV3) while voiced obstruents are non-inherently voiced (IV2). The voiced obstruents and the sonorants have different values, but the values are related by being adjacent on the IV scale. In some cases of assimilation an approach part way toward the sonorant ($1 \rightarrow 2 / \_ 3$) will occur. In other cases, where assimilation demands strict IV identity between the target and the trigger of the assimilation, sonorants will not cause voicing in obstruents. The topic of assimilation and attraction is taken up in Chapter 2.

Although assimilations involving stricture are rarer,[4] cases exist where stops become fricatives in the environment of fricatives and vowels, as voiced stops do in Spanish, Catalan and Basque (Mascaró 1984). This is analogous to the voicing of obstruents before voiced obstruents and sonorants. In terms of binary features, when a stop becomes a fricative due to a vowel, it is taking on a feature

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[2] The fact that sonorants have a different voicing than voiced obstruents is recognized in Chomsky & Hale (1968), who use spontaneous voicing as the defining charateristic of sonorants as opposed to obstruents. What is new in Rice & Avery and Rice's proposal is that sonorants are *not* given a [voice] feature, so that the SV node replaces SPE [sonorant] and [voice] (when it applied to sonorants).

[3] Indeed, as mentioned in 1.3, underspecification and later default fill-in are impossible in Optimality Theory, so that to the extent that Optimality Theory is accurate, a featural theory that avoids the need for these mechanisms comes out ahead.

[4] Perhaps because of dependencies between stricture and place. On such dependencies see Selkirk (1991) and Padgett (1991, *et seq*.).

[+continuant] which is redundant in vowels and thus unspecified in many approaches. [+continuant] would later have to be filled in. In such an approach (as with voicing in obstruents and sonorants), the fricatives and vowels have the same feature, but they have it at different times: fricatives always have it, and vowels only have it near the end of a derivation. The current framework does not rely on the different-timing approach of underspecification. Rather it sees fricatives and vowels as possessing different stricture values (CS 2 and 3, respectively). A fricative is closer to a vowel than a stop is, and the phonology is permitted to refer to this closeness by using a scale. In this way attraction of a stop to a fricative in the environment of a vowel can receive a natural explanation in the ternary scales model.

1.2 Other Scalar Proposals

This dissertation follows in the wake of a number of proposals which have sought to incorporate scales or multivalued features into phonological theory. These proposals can be divided into three basic types: those which concern vowel height, those which use the Sonority Hierarchy, and those which concern consonantal features. (A less well represented type of proposal is that of Stahlke (1977), who proposes scalar features for tone.)

Of the three topics listed above, the Sonority Hierarchy has received the most attention and the most acceptance. Work on the Sonority Hierarchy predates the advent of binary features (e.g. Sievers 1881, Jespersen 1904, de Saussure 1916) and has continued (e.g. Foley 1970, 1977; Vennemann 1972, 1988; Zwicky 1972, Hankamer & Aissen 1974, Hooper 1976, Escure 1977, Farmer-Lekach 1979, Steriade 1982, Selkirk 1984, Dell & Elmedlaoui 1985, Levin 1985, Zec 1988, Clements 1990, Prince & Smolensky 1993). Many who work with the Sonority Hierarchy have remained silent on whether they consider the Sonority

Hierarchy to be a basic unit of the phonology or a derived one. Others, e.g. Farmer-Lekach (1979), Steriade (1982), Levin (1985), Clements (1990), have given the Sonority Heirarchy a derivation that stems from binary features, so that the Sonority Heirarchy has not been perceived as a threat to basic binarity. Selkirk (1984), on the other hand, presents a true multivalued-feature proposal in that she seeks to replace the binary major class features [sonorant], [continuant] and [consonantal] by values on the Sonority Hierarchy. The present approach also does away with these features, replacing them with values on a scale. I argue, however, that the basic scales of the phonology are smaller than the Sonority Hierarchy, and that the Sonority Hierarchy is composed of these smaller ternary scales.

The next most popular scalar topic has been that of vowel height. Scalar vowel height features have been proposed by Contreras (1969), Smith (1970/1), Saltarelli (1973), Ladefoged (1975), Williamson (1977), Rivas (1977) and Lindau (1978). Evidence used to attack binary-featured vowel height include the absence of $\begin{bmatrix}\text{+high} \\ \text{+low}\end{bmatrix}$ (Saltarelli 1973, Williamson 1977, Rivas 1977) , the presence of four distinctive vowel heights in a language (Smith 1970/1), and the presence of scalar relationships between adjacent vowel heights (Saltarelli 1973, Lindau 1978). Besides these, Trigo (1991) presents a vowel scale based on diminutivization processes, but shows that it can be derived from binary features. Clements (1991a) is a sort of compromise case, in that he derives a height scale by the iterative operation of a privative [open] feature.

Efforts to make vowel height scalar were doomed from the start, because of the prior argument made by Halle (1957) that since vowel height is the only area of phonology that seems to require extra-binary features, it is therefore best to analyze vowel height using binary features as well. Halle states

> Only in the case of the feature *diffuse-nondiffuse* has the insistence upon binary features led us to introduce a parameter which has an extremely restricted applicability and therefore may be said not to be optimal. It is for this reason that in previous formulations of the distinctive feature framework the feature *compact-noncompact* was defined as a ternary feature. In recent months we have been led to accept the more consistent solution of postulating two binary features in place of the ternary one, because, in connection with our work on evaluation procedures for alternative phonemic solutions, we found the consistently binary system fitted our requirements better than the mixed system previously used. (p.71)

As Halle says, a fully binary system was perceived as better than a mixed binary and ternary system postulated only to better include vowel height. Yip (1980) is working under this assumption when she provides an argument against vowel scales. She takes issue with Lindau's (1978) claims for scalar vowel features, showing that Lindau's example, Scanian Swedish, can be analyzed using binary features. The analysis is quite labored, requiring 'minus alpha' notation, but this cost is considered minimal compared with losing binarity.

Given this background to the binary-scalar arguement, I have left vowel height somewhat in the background. It follows that if other ternary scales can be shown to be operative in the phonology, then vowel height will no longer be an anomaly, and will be able to take its place naturally in a set of phonological scales. The present work seeks to show that other scales are indeed necessary, and then applies the framework to vowel height.

Proposals of scales for consonantal features (which would render the basic argument against scalar vowel height void) have been rarer and have never gained much acceptance or even attention. The work of Foley (1970 et seq.) is perhaps the most radical example. Foley criticizes SPE for being simply descriptive, not explanatory. He rejects binary features altogether and sets up a series of multi-valued scales with which he analyzes processes such as chain-shifts. It is not clear, however, how Foley's theory could handle phonological processes, such as straight-forward assimilation, which do not appear scalar; or how he would capture the concept of natural classes. This dissertation seeks to avoid this problem by showing how apparently binary processes are in reality subsets of scalar phenomena. In spite of poor reception of his theory generally, Foley's proposal of the 'resonance scale,' helped spark modern interest in the Sonority Hierarchy (also known as the Consonantal Strength Hierarchy) in works such as Vennemann (1972).

Ladefoged (1971, 1975) and Williamson (1977) also propose multivalued features. They both propose place features which are multivalued, but I leave place aside in this dissertation. Ladefoged (1975) uses a stricture feature with values [stop], [fricative], [approximant]. Among phonologists, acceptance of Ladefoged's proposal has probably been hindered by the fact that he proposes the values as a phonetician, without phonological applications. Williamson (1977) is an exception. She places Ladefoged's multivalued feature on a scale, giving the values the numbers 2, 1, 0, respectively, and adds the value X as the absence of any stricture. She shows that scalar stricture can be used to analyze cases of lenition (weakening) of consonants. I follow Ladefoged in the identification of the stricture values, as does Steriade's (1993) Aperture Node theory, where stop, fricative and vowel have values A_0, A_{fric} and A_{max} respectively. The difference between Steriade's theory and those like Williamson's and the present one is that in the latter theories the different stricture values are actually ordered on a scale. In terms of the ternary scales model, CS1 is next to CS2, which is next to CS3. The phonology refers to these scalar relations.

A number of researchers have pointed out that the absence of particular combinations of binary features such as $\begin{bmatrix}+\text{high}\\+\text{low}\end{bmatrix}$ suggest that certain binary features are inadequate or inaccurate (Saltarelli 1973, Williamson 1977, Rivas 1977). In using scales which are ternary I follow Rivas, who points to cases where the combination of two binary features predicts four classes, and yet only three of these exist. The binary features approach predicts the presence of $\begin{bmatrix}+\text{sonorant}\\-\text{voice}\end{bmatrix}$,[5] $\begin{bmatrix}+\text{high}\\+\text{low}\end{bmatrix}$ and $\begin{bmatrix}-\text{continuant}\\-\text{consonantal}\end{bmatrix}$, which must be arbitrarily ruled out. Rivas uses the absence of a predicted fourth natural class to argue for ternary hierarchies derived from the binary features. In his system the complement of the missing class (i.e. $\begin{bmatrix}-\text{high}\\-\text{low}\end{bmatrix}$, $\begin{bmatrix}+\text{continuant}\\+\text{consonantal}\end{bmatrix}$, and by extension $\begin{bmatrix}-\text{sonorant}\\+\text{voice}\end{bmatrix}$[6]) defines the middle value of each ternary hierarchy, with the other two occurring classes on either side. Going one step further I propose that the absence of a fourth natural class is evidence that binary features are inaccurate representations of phonological reality. Following the suggestions of Rivas, I use a system of ternary scales. Unlike Rivas, however, I do not derive the ternary scales from binary features. Rather, the ternary scales are the basic units of phonological representation.

The absence of a fourth class is dealt with in underspecification models by making [voice] noncontrastive in sonorants, or [continuant] noncontrastive in vocoids. The effect of stipulating such underspecification is to allow three voicing classes and three stricture classes. I make this ternarity basic in the phonology, and in so doing I avoid having to give different segment classes different feature values at different times in the derivation, as mentioned above.

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[5] I follow Mester & Itô (1989) and Lombardi (1991) in analyzing 'voiceless' sonorants as aspirated.
[6] Rivas does not consider the case the case of [voice] and [sonorant], presumably because he assumed the existence of phonologically voiceless sonorants.

The present proposal seeks not just to define and defend the presence of scales, but to create a model of phonology in which the scales operate naturally.

1.3 Theoretical Assumptions

The following chapters present a phonology based on ternary scales. I will be working in the general framework of Optimality Theory (Prince & Smolensky 1993) in which the phonology consists of a set of ranked output constraints. The constraints act only on the outputs and on the relation between inputs and outputs. The inputs are left unconstrained. For any given underlying form (or *input*) a function, Gen, supplies an exhaustive list of potential surface forms (or *outputs*). The candidate outputs are evaluated by a set of ranked, violable constraints. The ranking and violability of the constraints are crucial to the theory, since all constraints are assumed to be present in every language. The ranking of the constraints, not the constraints themselves, differ from language to language. This means that a particular constraint may be very important in one language but less important in another. The violability of the constraints means that a constraint may be countermanded by a higher-ranked constraint. The actual output is chosen by the hierarchy of constraints as the one that best satisfies the constraints according to their ranking.

Optimality Theory (OT) sets at odds two classes of constraints. One is the markedness constraints, which forbid phonological markedness. The other is the faithfulness constraints which require faithful preservation of underlying material, even if it is marked. The tension between these two sets of constraints is played out differently in each language.

A consequence of working within the Optimality framework is that one can not stipulate that a feature such as [voice] is unspecified in the input of a sonorant. Inputs are unconstrained. Furthermore, the constraints are evaluated in parallel, without a sequenced derivation, so that one can not rely on a late rule filling in default specification. The ternary scales framework does not require these mechanisms, and so works well within Optimality Theory, while theories which rely on underspecification at input and default fill-in later in the derivation do not.[7]

To evaluate faithfulness of the output to the input I will be proposing a set of constraints which are evaluated within Correspondence Theory (McCarthy & Prince 1994, 1995). In Correspondence Theory, the output is related to the input by a function. The relationship between input segments and output segments can be represented by coindexing corresponding input-output pairs. Whenever the output deviates from the input, the correspondence function will not be one of identity, and so at least one faithfulness constraint will be violated. I will be taking the approach of McCarthy & Prince that correspondence is mediated through segments. One type of faithfulness constraint demands that all (and only) the input segments have coindexed partners in the output, and that they occur in the same linear order. These segmental faithfulness constraints prohibit deletion, epenthesis, coalescence and metathesis. The other type of faithfulness constraint looks at the feature content of coindexed segments. If the coindexed segments don't bear the same features (here scale values), then the featural/scalar faithfulness constraints will be violated. The result of comparing features/scale values by comparing coindexed segments is that featural/scalar

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[7] But see Itô, Mester & Padgett (1993) for an interesting way of resolving underspecification within Optimality Theory. In their solution, a constraint rules out redundant featural values, such as voicing in sonorants. In cases of attraction, the feature [voice] is linked to an obstruent as well as to a sonorant. When thus linked the [voice] feature is not redundant, so it surfaces. Sonorants are therefore sometimes specificied for [voice] and sometimes not. Their solution crucially relies on the concept of redundancy of voicing in sonorants, which stipulates a relationship between two otherwise unrelated features, and on the availability of two different representations of sonorants. In the ternary model, the phonetic relationship between voicing and sonorance is encoded in the phonology explicitly by their being adjacent on the IV scale. Furthermore, each voicing class (voiceless, voiced obstruent, sonorant) has only one phonological specification.

faithfulness is only relevant where the input and the output each have a member of the coindexed pair. Cases of deletion and epenthesis involve faithfulness violations at the segmental level, but not featural/scalar faithfulness violations. This is because in deletion there is no output correspondent of the deleted input segment, while in epenthesis there is no input correspondent of the added output segment. A coindexed pair does not exist. On the other hand, cases of featural/scalar assimilation do cause violations of featural/scalar faithfulness constraints, since the output has different features/scale values than its coindexed input segment.

In the following chapters I will not be assuming any particular type of feature geometry. While the ternary scales framework challenges certain assumptions of classical feature geometry (see Clements 1985, Sagey 1986, McCarthy 1988), it is irrelevant to others. I therefore leave aside the question of any arrangement of features other than into ternary scales.

1.4 Outline of Dissertation

This dissertation explores the topic of ternary scales in the following way. Because the topic is very large and complicated, much of the dissertation is devoted to only one scale, the Inherent Voicing (IV) scale. The Consonantal Stricture (CS) and Vowel Height (VH) scales are examined in the final chapter.

Chapter 2 looks at processes of assimilation and attraction on the IV scale. Voicing assimilation in codas comes in many varieties across languages, some of which appear scalar and some of which do not. I show that the apparently non-scalar assimilations are a subset of a larger class of assimilations, which do require reference to the IV scale. Chapter 2 shows how all these assimilations can be derived from a single assimilation constraint that can be ranked in a number of different places with respect to faithfulness constraints which demand retention of underlying scale values and forbid addition of non-underlying values. The faithfulness constraints are naturally ranked so that a more prominent member of the scale demands more faithfulness.

Attraction is also considered in Chapter 2. Attraction is best seen as a reference to the ternarity of the scale. Unlike in a binary system where segments can only match or differ utterly from each other in a feature value, on a ternary scale segments can match scale values, have neighboring scale values, or have non-neighboring scale values. Having neighboring scale values is seen as a second best to having identical scale values. The presence of attraction in some languages and its absence in others can be derived from different constraint rankings.

Chapter 3 turns to chain shifts and chain-shift-like consonant mutations that occur on the IV scale. These have the general form voiceless → voiced → sonorant. As noted earlier, the shift from voiceless to voiced to sonorant serves as strong evidence for the ternary IV scale. While some chain shifts are morphologically driven and some are simply phonological, both types receive an analysis in Chapter 3. The stepwise character of the chain shift is shown to derive from faithfulness constraints that distinguish between movement to a neighboring scale value and movement to a farther, non-neighboring scale value.

Chapter 4 looks at markedness and neutralization on the IV scale, tying these phenomena into the framework developed in Chapter 2. The middle value of the scale, IV2, is marked. because its presence prohibits the scale from expressing a maximally dispersed binary distinction. The markedness of IV2 affects epenthesis patterns, phonemic inventories, and coda neutralization. The faithfulness constraints introduced in Chapter 2 come into play here to direct the outcome of neutralization.

Chapter 5 applies the lessons of the previous chapters to the CS and VH scales, prior to concluding. While certain questions regarding these scales remain to be resolved, the scalar framework can account for cases of attraction, assimilation, chain shift and neutralization that occur on the CS and VH scales. The Sonority Hierarchy can also be derived by a combination of the three scales considered in this dissertation.

In summary, the dissertation makes two basic points. First, ternary scales are necessary to model phenomena like attraction and chain shift, which have not been satisfactorily modelled heretofore. Secondly, processes which have been previously modelled with some success within binary or privative frameworks (such as voicing assimilation and neutralization) continue to receive natural accounts in the ternary framework. The conclusion is therefore that ternary scales capture a wider range of phonological phenomena than previous models restricted to binary or privative features.

CHAPTER 2

ASSIMILATION, ATTRACTION AND FAITHFULNESS ON THE INHERENT VOICING SCALE

> For I also am a man set under authority, having under me soldiers, and I say unto one, Go, and he goeth; and to another, Come, and he cometh; and to my servant, Do this, and he doeth it. *Luke 7:8*

2.1 Introduction

This chapter is devoted to the Inherent Voicing scale and the faithfulness constraints which regulate the assimilation and attraction processes which take place on it. The IV scale is shown in (1).

(1) The Inherent Voicing (IV) Scale
voiceless obstruent, voiced obstruent, sonorant (= IV1, IV2, IV3)

The scale in (1) is the scene of a number of assimilation processes. Some assimilations appear binary, in that they only affect voicing in obstruents. Some assimilations, on the other hand, involve all points of the ternary scale, in that voiceless obstruents (IV1) and voiced obstruents (IV2) may assimilate to sonorants (IV3), or sonorants (IV3) and voiced obstruents (IV2) may assimilate to voiceless obstruents (IV1). Other assimilations involve all the points of the scale in another fashion: voiceless obstruents (IV1) may become voiced (IV2) under the influence of a sonorant (IV3). This chapter shows that these different types of assimilation all take place on a ternary scale under the influence of a single set of constraints. The differences between the assimilation types are shown to derive from different constraint ranking.

The order of the ternary scale in (1) is such that the sonority ordering of the scale is reflected in the numbers: a higher number indicates higher sonority.[1] Higher sonority is the segmental form of higher prominence, as used by Prince &

[1] For the application of the ternary scales to the Sonority Hierarchy, see Chapter 5.

Smolensky (1993). I claim that the inherent prominence relations on the scale are translated into a universal ranking of faithfulness constraints. The ranking of these faithfulness constraints with respect to constraints requiring assimilation accounts for the voicing assimilation facts of various languages.

I propose that higher segmental prominence requires more highly ranked faithfulness constraints. This equation of higher prominence with higher faithfulness follows Beckman (1996), who shows that more prominent syllable positions require greater faithfulness; and Alderete (1995), who shows that segments with prosodic prominence also require greater faithfulness. Applying the prominence-faithfulness equation to a ternary scale leads to the fixed subhierarchy in (2), where 'FAITH X' means 'the set of faithfulness constraints which regulate the addition and loss of value X'.

(2) Prominence reflected in Faithfulness Constraints

FAITH 3 >> FAITH 2 >> FAITH 1

On the Inherent Voicing Scale this means that faithfulness to the IV specification of sonorants (IV3) is more highly ranked than faithfulness to the IV specification of voiced obstruents (IV2), which is more highly ranked than faithfulness to the IV specification of voiceless obstruents (IV1). Each ternary scale will have its own version of (2), with ranking independent of that of other scales. Here I restrict my attention to the IV scale.

If an output segment has a different IV value than its correspondent input segment, then it has violated the FAITH hierarchy in (2) in two different ways. Specifically, it has *taken on* a value not present in the input correspondent, and it has *ceased to have* a value which was present in the input segment. If a voiceless segment voices, then it has taken on the value IV2, and it has ceased to have the value IV1. If a voiced obstruent devoices, it has taken on the value IV1 and ceased to have the value IV2. The faithfulness constraints which regulate these deviations from identity between input and output fall into two families, one which forbids the addition of a new scale value, and one which forbids the loss of an underlying scale value. These are formulated in (3).

(3) Constraints on Faithfulness to Scale Values

a) RESIST X: If α is an input segment and β is an output correspondent of α, then if α does not possess a scale value X, then β does not possess X. (Intuitively, an output segment may not take on value X if the corresponding input segment does not possess value X)

b) STAY Y: If α is an input segment and β is an output correspondent of α, then if α possesses scale value Y, then β possesses scale value Y. (Intuitively, an output segment may not lose value Y if the corresponding input segment possesses it.)

RESIST X is violated by an output segment which has *taken on* (moved to) the value X, while STAY Y is violated by an output segment which has *ceased to have* (moved from) the value Y.

In using one constraint family forbidding the addition of values and another one forbidding the loss of values I follow Pater (1995) who splits McCarthy & Prince's (1995) IDENT family into two, with IDENT i→o forbidding loss of a feature and IDENT o→i forbidding the addition of a feature. The use of two constraint families, STAY and RESIST, is essential, since other constraints may rank between the STAY and RESIST constraints on a given scale value. This will be the case in sections 2.3.1, 2.3.2, 2.4.1 and 2.4.2.

Each output segment that possesses a different scale value than its input correspondent incurs one STAY violation and one RESIST violation, since it has ceased to have one value and taken on another. The table in (4) illustrates the action of the constraints.

(4) Violations of STAY and RESIST

Input	Output	STAY 3	STAY 2	STAY 1	RESIST 3	RESIST 2	RESIST 1
p	b			*		*	
p	m			*	*		
b	p		*				*
b	m		*		*		
m	b	*				*	
m	p	*					*

In the first two lines of table (4), the voiceless obstruent violates STAY 1 whenever it changes its IV value. If it voices it violates RESIST 2, and if it becomes a sonorant it violates RESIST 3. Similarly, the voiced obstruent violates STAY 2 whenever it moves on the IV scale. If it devoices it violates RESIST 1, and if it becomes a sonorant it violates RESIST 3. Likewise the sonorant always violates STAY 3 if it changes its value on the IV scale. Like the voiceless obstruent it violates RESIST 2 if it becomes a voiced obstruent, and like the voiced obstruent it violates RESIST 1 if it becomes a voiceless sonorant.

In accordance with the ranking in (2), the STAY and RESIST constraints fall into fixed subhierarchies. STAY 3 is always ranked above STAY 2, and STAY 2 is always ranked above STAY 1. Similarly RESIST 3 is always ranked above RESIST 2, which is always ranked above RESIST 1. This is shown in (5).

(5) Universal Ranking of STAY and RESIST Subhierarchies

a) STAY 3 >> STAY 2 >> STAY 1

b) RESIST 3 >> RESIST 2 >> RESIST 1

The universal rankings in (5) mean that it is always worse for a sonorant to lose its sonorance (violating STAY 3) than for an obstruent to devoice (violating STAY 2). Similarly, it is always worse for an obstruent to become a sonorant (violating RESIST 3) than for a voiceless obstruent to become a voiced obstruent (violating RESIST 2).

The hierarchy in (2) means more than just the rankings in (5), however. As the FAITH hierarchy is stated in (2), all the faithfulness constraints on IV3 must outrank all the faithfulness constraints on IV2, which must outrank all the faithfulness constraints on IV1. This means that both STAY 3 and RESIST 3 outrank both STAY 2 and RESIST 2, which outrank both STAY 1 and RESIST 1. The situation can be illustrated as in (6).

(6) Ranking of the combined STAY and RESIST subhierarchies

FAITH 3 >> FAITH 2 >> FAITH 1

STAY 3 RESIST 3 STAY 2 RESIST 2 STAY 1 RESIST 1

As (6) shows, the set of faithfulness constraints referring to IV3 dominate the set of faithfulness constraints referring to IV2, which dominate the set of faithfulness constraints referring to IV1. This is shown by the domination signs (>>) separating FAITH 3, FAITH 2 and FAITH 1. As the constituent structure shows, 'FAITH' is a superordinate term comprising STAY and RESIST. Within the set of FAITH 3, STAY 3 and RESIST 3 are not universally ranked, and similarly for levels 2 and 1. This is indicated by the lack of domination signs between the STAY and RESIST constraints. This means that languages are free to rank RESIST above STAY or STAY above RESIST. This choice and the ability of assimilation constraints to intervene anywhere among the faithfulness constraints provides the rich typology of voicing assimilations seen in the worlds languages.

It may well be that in a given language if STAY 3 dominates RESIST 3 then STAY 2 dominates RESIST 2 and STAY 1 dominates RESIST 1. In other words, it may be the case that STAY dominates RESIST at each level in some languages, while RESIST dominates STAY in other languages, but that a ranking like STAY 3 >> RESIST 3 >> RESIST 2 >> STAY 2 is forbidden. Thus a single ranking (STAY >>

RESIST or RESIST >> STAY) need be determined for each language. In the absence of evidence to the contrary I will assume this symmetrical type of ranking.

In summary, this section has presented the faithfulness constraints that refer to the individual values of a ternary scale, here applied to the Inherent Voicing Scale. Whenever a segment changes its IV value, it incurs a STAY violation for the value that it has lost, and a RESIST violation for the value it has taken on. Prominence on the scale is reflected in greater faithfulness, so that RESIST 3 and STAY 3 dominate RESIST 2 and STAY 2, which dominate RESIST 1 and STAY 1. The ranking between STAY and RESIST is not universally fixed, and both rankings are found in the languages to be discussed in this chapter. The ranking of other constraints, such as those calling for assimilation, at various points in the faithfulness hierarchy (including between STAY and RESIST of a particular level) yields a number of different voicing processes attested in the world's languages.[2] I turn next to an example that demonstrates the action of the faithfulness constraints and their ranking.

2.1.1 Hungarian Voicing: Exemplifying IV Faithfulness

This section introduces the faithfulness constraints more fully and provides evidence for their ranking on the basis of the fairly simple voicing assimilations in Hungarian. While Hungarian does not in itself demand a ternary analysis, I use it to illustrate the ranking of the constraints which will later be applied to more obviously ternary cases. Consider the following voicing facts in Hungarian. Before a voiced obstruent (IV2) a coda obstruent will be voiced. Before a voiceless obstruent (IV1) a coda obstruent will be voiceless. Before a sonorant (IV3) an obstruent retains its underlying IV value. Sonorants before obstruents also retain their underlying value. Examples of the Hungarian

[2] For a complete picture of processes possible on a ternary scale the relative faithfulness constraints discussed in Chapter 3 are also required.

IV processes are shown in (7) (from J. Radó, p.c.). The examples are given in Hungarian orthography, which reflects the underlying forms for the relevant segments. The relevant segments are shown in bold within the word. The surface forms of the segments are transcribed in brackets to the right of the word. That all the relevant segments are in syllable codas is confirmed by Vago (1989), who states that only one consonant can appear in a syllable onset word internally (with some exceptions in loan words and onomatopoeia).

(7) IV Assimilation of Obstruents in Hungarian

a. IV contrasts in isolation

na**p** [p.] 'day, sun' IV1
ba**b** [b.] 'bean' IV2
ro**m** [m.] 'ruin' IV3

b. Voiceless assimilate to voiced (IV1 → IV2)

té**p**des [b.] 'tear, frequentive'
lö**k**dös [g.] 'shove, frequentive'

c. Voiced assimilate to voiceless (IV2 → IV1)

me**g**talál [k.] 'find, perfective, 3p. sing.'
ren**d**kívul [t.] 'unusual'
é**v**tized [f.] 'decade'

d. No change of obstruent before sonorant

na**p**nyugta [p.] 'sunset 1'
na**p**lemente [p.] 'sunset 2'
me**g**magyaráz [g.] 'explain, perfective, 3p. sing.'
me**g**lát [g.] 'catch sight of, perfective, 3p. sing.'

e. No change of sonorant before obstruent

ké**n**kő [n.] 'sulfur stone'
ké**n**dioxid [n.] 'sulfur dioxide'
nyo**m**kod [m.] 'presses repeatedly'
nyo**m**da [m.] 'publishing press'

As (7) shows, obstruents can assimilate by devoicing before voiceless obstruents or by voicing before voiced obstruents but not by becoming sonorant. A sonorant can not assimilate in voicing to an obstruent. In other words, the values IV1 and IV2 can be lost or acquired, but sonorants (IV3) can neither be created nor destroyed.

The coda obstruents in (7) undergo assimilation on the Inherent Voicing scale. Assimilation constraints require adjacent segments to have identical scale values. They have the general form in (8). (The formulation of assimilation constraints will be discussed further and refined in section 2.5.)

(8) ASSIM: The output {scale} value of adjacent segments must be identical

There will naturally be an ASSIM constraint for each scale (or, alternatively, the difference in assimilation across scales could be due to the different ranking of the faithfulness constraints on the different scales). I leave aside here the question of what (other than adjacency) might make a particular segment subject to the force of assimilation, and on what tiers the adjacency is evaluated. Whether the segment resists or submits to the force of assimilation, on the other hand, is decided by the faithfulness constraints. In the following sections I will be looking especially at the assimilation of codas to following onsets. Given that the ASSIM constraint in (8) commands that the coda and following onset have identical IV values, either the coda or the onset must in many cases be changed to satisfy it. According to Beckman's (1995, 1996) positional faithfulness (also Selkirk 1994), onsets receive higher faithfulness than codas. Beckman captures this by assigning onsets special faithfulness constraints in addition to the general faithfulness constraints, so that for any given faithfulness constraint FAITH there is a FAITH-onset constraint in addition to a general FAITH. Translating this to the ternary system, we can say that FAITH 3-onset >> FAITH 3, and FAITH 2-onset >> FAITH 2, and FAITH 1-onset >> FAITH 1.[3] The codas will therefore assimilate to the

[3] While the general approach of extra faithfulness constraints for onsets does not imply that the onset constraints must be more highly ranked, when faithfulness constraints are broken up into STAY and RESIST (or IDENT i→o and IDENT o→i, or MAX and DEP) components, free ranking

onsets, and not *vice versa*.[4] In what follows the ranking of onset faithfulness above coda faithfulness is assumed, and only coda violations of faithfulness will be considered.[5]

An ASSIM constraint is violated whenever the two segments it is evaluating have different values on the relevant scale. In evaluating codas and following onsets, the ASSIM constraint will be violated whenever the scale value of the coda is different from that of the following onset. The ASSIM constraint is therefore responsible for the IV assimilations in Hungarian. Under the force of this constraint an input segment with an IV1 value will lose this value and take on an output value 2 in the environment of IV2. An input with value IV2 already satisfies the constraint in this environment, so it need not change. If the IV2 segment is in an IV1 environment, the ASSIM constraint forces it to give up its IV2 value and take on IV1. When the assimilation trigger is a sonorant (IV3), ASSIM fails to have an effect. ASSIM also fails to have an effect on an input IV3, regardless of the IV value of the following onset. The effects of ASSIM in Hungarian are summarized below.

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between the general faithfulness constraints and the specific onset faithfulness constraints can lead to incorrect results. This can be avoided by ranking each onset faithfulness constraint on a feature/scale value above the general faithfulness constraint, as I have done above.

[4] While codas assimilating to onsets is the general pattern, the reverse does occur, especially after nasals, and occasionally other sonorants (as in Southern Italian, Chapter 3.1). In such cases there must be other factors at work. What remains clear, however, is that codas assimilating to onsets is the more standard pattern, and that positional faithfulness handles this very well.

[5] Although I have chosen to represent coda assimilation as due to positional faithfulness, another possibility for capturing the difference between codas and onsets in assimilation is to subject the codas to a specific version of the ASSIM constraint that targets only codas.

(9) Effects of ASSIM in Hungarian

a) Effects on Voiceless Obstruents (IV1)

Input	Output	Trigger	Result
p voiceless obstruent IV1	b voiced obstruent IV2	d voiced obstruent IV2	ASSIM satisfied
p voiceless obstruent IV1	p voiced obstruent IV1	n sonorant IV3	ASSIM violated

b) Effects on Voiced Obstruents (IV2)

Input	Output	Trigger	Result
b voiced obstruent IV2	p voiced obstruent IV1	t voiceless obstruent IV1	ASSIM satisfied
b voiced obstruent IV2	b voiced obstruent IV2	n sonorant IV3	ASSIM violated

c) Effects on Sonorants (IV3)

Input	Output	Trigger	Result
m sonorant IV3	m sonorant IV3	t voiceless obstruent IV1	ASSIM violated
m sonorant IV3	m sonorant IV3	d voiced obstruent IV2	ASSIM violated

The present case of IV assimilation shows that in Hungarian the ASSIM constraint is violated whenever satisfying it would require the addition or loss of an IV3 specification. The ASSIM constraint is highly enough ranked to cause voicing (the addition of IV2), but not highly enough ranked to create sonorants (by addition of IV3). The ASSIM constraint is also highly enough ranked to cause loss of voicing (loss of IV2), but not highly enough ranked to cause loss of sonorance (loss of IV3). The failure of ASSIM to force the creation of sonorants from obstruents or obstruents from sonorants is due to the ranking of faithfulness constraints introduced in section 2.1 above. ASSIM must rank above the faithfulness constraints on IV1 and IV2, but below the faithfulness constraints on IV3. The ranking of ASSIM and the faithfulness constraints will be discussed more fully in the succeeding paragraphs.

I consider first the behavior of voiceless obstruents (IV1), as outlined in table (9a). Before an onset voiced obstruent (IV2) a coda voiceless obstruent will become voiced. Thus the underlying /p/ in *té**pd**es* becomes *b*. The force behind this change in IV value is the constraint ASSIM, introduced in (8). Under pressure from ASSIM the faithfulness constraints STAY 1 and RESIST 2 are violated. This is because the underlying voiceless obstruent has ceased to be IV1 (violating STAY 1) and taken on IV2 (violating RESIST 2). The assimilation of voiceless obstruents motivate the rankings in (10).

(10) Rankings motivated by IV1 → IV2

ASSIM >> STAY 1

ASSIM >> RESIST 2

The rankings in (10) are demonstrated in tableau (11).

(11) Voicing of Obstruents before Voiced Obstruents

té**pd**es	ASSIM	RESIST 2	STAY 1
p.d → p.d	*!		
√ p.d → b.d		*	*

As (11) shows, the faithful first candidate which fails to satisfy ASSIM is eliminated, since the second candidate can satisfy ASSIM by violating the lower ranked RESIST 2 and STAY 1 instead.

A voiceless obstruent does not assimilate to a sonorant (IV3). The /p/ in *na**pn**yugta* surfaces as *p*. This means that RESIST 3 can not be violated under pressure from ASSIM. The IV3 value may not be added to satisfy assimilation requirements. From (10) we know that the IV1 value can be lost. The failure of assimilation to IV3 does not lie in what value is being lost, but in what value is being added. While IV1 may be lost, IV3 can not be added. This leads the ranking in (12).

(12) Ranking motivated by lack of IV1 → IV3.
RESIST 3 >> ASSIM

Given that RESIST 3 can not be violated to satisfy ASSIM, the voiceless obstruent remains voiceless in the presence of a sonorant. This does not mean that the onset sonorant is not an assimilation trigger for ASSIM. Rather the higher ranked faithfulness constraint RESIST 3 forbids the obstruent to obey ASSIM. If the obstruent were to simply voice in the environment of the sonorant, it would violate RESIST 2 without satisfying ASSIM. ASSIM demands IV identity between coda and onset, which is not met if the coda is a voiced obstruent (IV2) and the onset is a sonorant (IV3). So voicing the obstruent in the environment of the sonorant is fruitless. If assimilation is forced to fail the fallback is simply to remain faithful to the underlying value. The lack of assimilation to sonorants does not mean that sonorants are unspecified for a voicing value. Rather they have their own value, IV3, which is separate from the IV2 value of voiced obstruents.[6] The ranking in (12),which prohibits assimilation to sonorants, is demonstrated in tableau (13).

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[6] Cases of IV attraction, where sonorants trigger voicing in obstruents (IV1 —> IV2/ __ IV3), and the difference between attracting and non-attracting languages is discussed in section 2.6.

(13) Obstruents fail to assimilate to Sonorants

na**pn**yugta	RESIST 3	ASSIM	RESIST 2	STAY 1
√ p.n → p.n		*		
p.n → b.n		*	*!	*
p.n → m.n	*!			*

As (13) shows, a violation of RESIST 3 is fatal to the third candidate. For the second candidate, violating RESIST 2 is fatal, since it does not avoid a violation of ASSIM. The best candidate is thus the one that is fully faithful to the input, despite the violation of ASSIM.

Consider next the case of the voiced obstruents (IV2). In the environment of voiceless obstruents (IV1), the voiced obstruents devoice, so the /g/ in *me**gt**alál* becomes *k*. This means that the ASSIM constraint can force a segment to lose an IV2 value (violating STAY 2) and to take on an IV1 value (violating RESIST 1). This motivates the rankings in (14).

(14) Rankings motivated by IV2 → IV1
ASSIM >> RESIST 1
ASSIM >> STAY 2

The rankings in (14) are demonstrated in tableau (15).

(15) Devoicing of Obstruents before Voiced Obstruents

me**gt**alál	ASSIM	STAY 2	RESIST 1
g.t → g.t	*!		
√ g.t → k.t		*	*

As (15) shows, STAY 2 and RESIST 1 can both be violated in order to satisfy ASSIM. The first candidate, which does not satisfy ASSIM is eliminated. The second candidate is thus the winner in spite of its violations of STAY 2 and RESIST 1. So voiced obstruents (IV2) devoice in order to assimilate to voiceless obstruents (IV1).

Like the voiceless obstruents, voiced obstruents do not become sonorants in the environment of sonorants. In *me**gm**agyaráz* the /g/ remains *g*. As seen in (12) and (13), this is because of the high ranking of RESIST 3. RESIST 3 dominates ASSIM, so sonorants can not be created through assimilation of codas regardless of the ranking of the other relevant faithfulness constraint, STAY 2. The case of the voiced obstruent before a sonorant is thus essentially like the case of the voiceless obstruent before a sonorant, as in tableau (13).

Sonorants do not assimilate to obstruents. In scalar terms, IV3 can not be lost, regardless of whether the attempted landing site is IV2 or IV1. So the /m/ in *nyom* 'press' remains *m*, regardless of whether it is followed by /k/ in *nyo**mk**od* 'presses repeatedly' or by /d/ in *nyo**md**a* 'publishing press'. ASSIM has no effect on an underlying IV3 value. This fact motivates the ranking in (16).

(16) Ranking motivated by lack of assimilation of sonorants
STAY 3 >> ASSIM

STAY 3, which demands that underlying IV3 values be retained, is too highly ranked to allow sonorance to be lost for the sake of assimilation. This does not mean that sonorants are not targeted by the ASSIM constraint. Rather, the demands of the faithfulness constraint STAY 3 conflict with those of ASSIM, and the more highly ranked STAY 3 wins. This is demonstrated in tableau (17) for attempted assimilation of a sonorant to a voiceless obstruent.

(17) Sonorants do not assimilate to Obstruents

nyo**mk**od	STAY 3	ASSIM	RESIST 2	RESIST 1
√ m.k → m.k		*		
m.k → b.k	*!	*	*	
m.k → p.k	*!			*

As the final candidate in (17) shows, violating STAY 3 is a fatal violation. The candidate has assimilated, but in so doing has violated the top-ranked STAY 3. As the second candidate shows, movement partway toward the voiceless obstruent is pointless. It still violates STAY 3. Only the faithful candidate on the first line avoids violating the top ranked STAY 3. It is thus the winning candidate despite its failure to assimilate. Assimilation of the sonorant to a voiced obstruent would also be doomed to failure due to the high ranking of STAY 3 shown in tableau (17).

The full ranking motivated by the Hungarian assimilations facts is given in (18). Sonorants are neither created or destroyed, so RESIST 3 and STAY 3 dominate ASSIM. Obstruents voice and devoice in order to assimilate to each other, so ASSIM dominates RESIST 2, RESIST 1, STAY 2 and STAY 1.

(18) Full Rankings motivated by Hungarian

STAY 3 >>   >> STAY 2, STAY 1

                ASSIM

RESIST 3 >>   >> RESIST 2, RESIST 1

The ranking in (18) shows that not only does ASSIM outrank STAY 2, but STAY 3 does as well. Likewise the ranking of ASSIM between RESIST 3 and RESIST 2 shows that RESIST 3 dominates RESIST 2. ASSIM is intervening in the STAY and RESIST subhierarchies and providing evidence as to the ranking within the hierarchies. These subhierarchies, I claim, are universally ordered. Universally it is easier to voice an obstruent (violating RESIST 2) than it is to make an obstruent into a sonorant (violating RESIST 3). Similarly it is universally easier to lose obstruent voicing (violating STAY 2) than it is to lose sonorant voicing (violating STAY 3). So universally RESIST 3 dominates RESIST 2 and STAY 3 dominates STAY 2.

What the ranking in (18) does not show is the domination of STAY 2 over STAY 1 and RESIST 2 over RESIST 1, which I also claim is part of the universal faithfulness subhierarchy. Although Hungarian does not exhibit direct evidence for the ranking of RESIST 2 over RESIST 1, it does have evidence that RESIST 1, like RESIST 2, is ranked below ASSIM (and thus also below RESIST 3). This is because voiceless obstruents are created under the force of the ASSIM constraint, violating RESIST 1. STAY 1, like STAY 2, is also ranked below ASSIM, and thus below STAY 3. This is because voiceless obstruents lose their IV1 specification (violating STAY 1) when becoming voiced (IV2) under assimilation. To complete the ranking and show the domination of STAY 2 over STAY 1 (or RESIST 2 over RESIST 1) requires a language where ASSIM ranks between STAY 2 and STAY 1 (or between RESIST 2 and RESIST 1). Cases of such languages will be discussed in the succeeding sections.

The ranking in (18) shows that both STAY 3 and RESIST 3 outrank STAY 2 and RESIST 2. I claim that this is in fact universal: the faithfulness constraints referring to the third value on the scale both outrank those referring to the second level, and those referring to the second level both outrank those referring to the first level. The ranking between STAY and RESIST, however, is free to be determined on a language-specific basis. In the Hungarian case, the ranking is not determinable. In other languages ASSIM ranks between STAY and RESIST on a particular level and shows up their relative ranking. The universal aspect of the ranking is given in (19). The position of the domination signs is intended to emphasize that both RESIST and STAY at a particular level dominate both RESIST and STAY at the next level, but the RESIST and STAY constraints within a level are not universally ranked with respect to each other.

(19) Universal Faithfulness Rankings

RESIST 3		RESIST 2		RESIST 1
	>>		>>	
STAY 3	STAY 2	STAY 1		

In Hungarian ASSIM ranks between RESIST 3 and STAY 3 on the one hand and RESIST 2 and STAY 2 on the other. The RESIST and STAY hierarchies are fixed, but ASSIM is free to be ranked anywhere among the constraints in (19). The succeeding tableaux summarize the effects of the ranking of ASSIM with respect to the universal STAY and RESIST hierarchies in Hungarian. Tableau (20a) shows the voicing of obstruents before voiced obstruents, and (20b) shows the devoicing of obstruents before voiceless obstruents. Tableau (20c) shows how the Hungarian ranking accounts for the resistance of sonorants to assimilation, while (d) shows the failure of obstruents to assimilate to sonorants.

(20) Assimilation tableaux for Hungarian

a) Voicing of obstruents before voiced obstruents

/…p.d…/	RESIST 3	STAY 3	ASSIM	RESIST 2	STAY 2	RESIST 1	STAY 1
p.d			*!				
√ b.d				*			*

b) Devoicing of obstruents before voiceless obstruents

/…g.t…/	RESIST 3	STAY 3	ASSIM	RESIST 2	STAY 2	RESIST 1	STAY 1
√ k.t					*	*	
g.t			*!				

c) Resistance of sonorants to assimilation

/…m.k…/	RESIST 3	STAY 3	ASSIM	RESIST 2	STAY 2	RESIST 1	STAY 1
p.k		*!				*	
b.k		*!	*	*			

√ m.k			*				

d) Failure of obstruents to assimilate to sonorants

	RESIST 3	STAY 3	ASSIM	RESIST 2	STAY 2	RESIST 1	STAY 1
√ p.n → p.n			*				
p.n → b.n			*	*!			*
p.n → m.n	*!						*

The tableaux in (20) show how a simple ranking of the scalar faithfulness constraints with respect to the assimilation constraint ASSIM can account for the voicing assimilation of obstruents in Hungarian and the lack of IV scale assimilation in sonorants. STAY 3 and RESIST 3 are ranked too highly to allow sonorants to be created or lost, as shown in (20c) and (d). The faithfulness constraints at levels 1 and 2 rank lower, and both voicing and devoicing assimilation occurs in obstruents, as in (20a) and (b). Later sections turn to other rankings of ASSIM which are attested in other languages.

2.1.2 Discussion

The previous section showed how a ranking of an assimilation constraint ASSIM below STAY 3 and RESIST 3 but above STAY 2 and RESIST 2 yielded a situation where coda obstruents agree in voicing with following onset obstruents but retain their underlying voicing value finally and before a sonorant. Coda sonorants also did not assimilate. The representation of these voicing facts as due to a ranking of ASSIM among universal scalar faithfulness constraints differs significantly from previous approaches to voicing assimilations. This section discusses some areas where the ternary scales model differs most from previous models with the aim of clarifying and justifying these differences.

One important aspect of the ternary scales model is that it allows full specification of scalar values. In a model of voicing assimilation such as that in

Itô & Mester (1986), Lombardi (1991, 1995) or Abu-Mansour (1994) the voiced obstruents are the only segments that are specified for a voicing value for much of the derivation. Voiceless obstruents have no specification of the [voice] feature. Sonorants begin the derivation with a [sonorant] feature but no voicing feature. The [sonorant] feature and the [voice] feature are representationally unrelated but the presence of the [sonorant] feature implies that the [voice] feature will be added at some late point in the derivation (or, in OT translations of these theories, such as Itô, Mester & Padgett (1993), the [voice] feature will be added under certain circumstances).

I turn first to the idea of privativity of [voice], or underspecification of a voicing value in voiceless obstruents. The original motivation for this idea was an apparent redundancy between voicing assimilations and neutralization of voicing in codas. In codas, many languages neutralize obstruents so that voiced obstruents become voiceless syllable finally. If, on the other hand, there is an assimilation process whereby obstruents become devoiced before voiceless obstruents, then there are two processes operating on codas that yield the same result. Furthermore, if neutralization represents the loss of some structure, then it makes sense to say that [voice] is lost and that the absence of [voice] means that a segment is voiceless. Then voicelessness is always represented by a lack of a [voice] node. An absence of a node is not something that can be assimilated to, so the apparent assimilation to voicelessness is simply neutralization.

This argument rests crucially on the assumption that neutralization is loss of feature geometric structure. This is not necessarily the case. In Chapter 4 I analyze neutralization as being due to the general markedness of the middle value on the scale. A marked value will easily be lost in codas, where faithfulness is less valued than in other syllabic positions. Once the IV2 value is lost the universal faithfulness constraints will determine that the IV1 value is substituted, since RESIST 1 is the lowest ranked RESIST constraint. Chapter 4 will describe this in more detail. The point here is that the universal ranking of the scalar faithfulness constraints determines the outcome of neutralization independently of any feature geometry.[7]

In the ternary scales model, then, voiceless obstruents need not be underspecified in order to be the result of neutralization. Voiceless obstruents are the result of neutralization because they have low ranking faithfulness constraints. The IV1 value has the lowest ranked faithfulness constrains, but it is still a value on the scale. This means that it can trigger assimilation. I claim that there is true voicelessness (IV1) assimilation that can not be described as neutralization. Hungarian provides just such an example. In Hungarian there is no neutralization of voiced obstruents finally (see (7a)). There is also no neutralization of voiced obstruents before sonorants (see (7d)). Devoicing only occurs before voiceless obstruents.

The lack of neutralization word finally in a case like Hungarian is explained by Lombardi (1991) as final exceptionality: word-finally some features may be licensed that would not otherwise be licensed. Lombardi explains the lack of neutralization of obstruents before sonorants by ordering the neutralization after the default fill-in of [voice] on sonorants and by fusing the [voice] specification of the obstruent with that of the sonorant. The fusion renders the obstruent immune to neutralization.

The present model, on the other hand, allows assimilation to voicelessness (IV1). The Hungarian facts are therefore not surprising and do not call for any extra explanations such as fusion or final exceptionality. Voiced obstruents (IV2) assimilate to voiceless obstruents (IV1) under the pressure of ASSIM. When there

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[7] It is important to note that while the universal faithfulness subhierarchy determines the *outcome* of neutralization, it does not provide the *motivation* for the neutralization, which is provided by a markedness constraint.

is no following voiceless obstruent the voiced obstruent retains its underlying value and does not neutralize.[8] Assimilation to IV1 is the simplest explanation of the Hungarian devoicing. When the need to see neutralization as loss of a node is removed, there is no motivation for making voicelessness assimilation into neutralization. Indeed, as shown in section 2.4.2, even sonorants can assimilate to voiceless obstruents, so taking assimilation to voicelessness as neutralization of voiced obstruents can not capture the range of observed assimilations.

I turn next to the issue of specification in sonorants. Lombardi (1991) analyzes their frequent lack of participation in voicing as due to their lack of a [voice] node for most of the phonological derivation. More recent approaches within OT (e.g. Itô, Mester & Padgett 1993 and Selkirk 1994) do not require an ordered derivation. All of these approaches, however, rely on a redundancy relation between [voice] and [sonorant]. At some point in the ordered derivation (or at some point in the constraint hierarchy) the feature [sonorant] implies [voice], but not the reverse. This relation can not be stated naturally within the binary (or privative) feature framework.

In the ternary scales model, as in Lombardi's model, a sonorant does not have the voicing value of a voiced obstruent. In other words, IV3 is separate from IV2. This is similar to Rice & Avery's (1989) use of a Sonorant Voicing node to describe sonorants. In the ternary scales model, however, the sonorant's IV3 value is naturally related to a voiced obstruent's IV2 value. The two values are adjacent. They both represent higher voicing values than that of voiceless obstruents. In the structure of the scale the relation between voiced obstruents and sonorants, previously made with default or redundant specification, is made explicit in the featural/scalar structure.

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[8] In other languages the voiced obstruent could still neutralize if the markedness constraint responsible for neturalization was highly enough ranked. See Chapter 4 for further discussion.

In a sense the ternary scales model is one of radical privativity: only sonorants can have value IV3 and there is no '–IV3'. Similarly only voiced obstruents may have the value IV2 and there is no '–IV2'. The same can be said for IV1. The three voicing classes have three different specifications. The key, however, is that they are related to each other on the IV scale. There is no independent [voice] feature. Rather, there are different types of voicing. IV3 implies 'more', or more natural, voicing than IV2 and IV2 implies 'more' voicing than IV1. The degree of voicing is reflected in the prominence ranking on the Inherent Voicing scale, which in turn is reflected in the ranking of the scalar faithfulness constraints. The universal ranking of the faithfulness constraints accounts for the relative rareness of sonorant assimilations (violating high ranked STAY 3 or RESIST 3) and also for the fact that voiceless obstruents are the result of voicing neutralization (violating RESIST 1, as discussed more fully in Chapter 4).

The prominence-faithfulness equation, when applied to a ternary scale, gives the universal faithfulness rankings repeated in (23). The ranking of both STAY 3 and RESIST 3 over both STAY 2 and RESIST 2 (and similarly for value 1) is not the only possible interpretation of the equation, but in the absence of evidence to the contrary I claim that it is the only interpretation available to actual languages.

(21) Prominence translated into higher faithfulness

STAY 3		STAY 2		STAY 1		
	>>				>>	
RESIST 3			RESIST 2			RESIST 1

The rest of this chapter discusses the interaction between the fixed faithfulness ranking in (21) and assimilation constraints. In the Hungarian case sonorants played no role in coda assimilations due to the ranking of ASSIM below STAY 3 and RESIST 3. The STAY and RESIST subhierarchies, I have claimed, are universally ranked, so that STAY 3 and RESIST 3 will always be highly ranked.

Due to the universal form of the faithfulness subhierarchies, assimilations involving sonorants as inputs or outputs will be relatively rare. Such assimilations violate STAY 3 or RESIST 3, which are always highly ranked. Nevertheless assimilations violating STAY 3 or RESIST 3 should occasionally be met with, since the ASSIM is freely rankable. The following sections provide examples showing that this is indeed the case by providing a typology of rankings of ASSIM with respect to the scalar faithfulness constraints. Section 2.2 discusses the rankings which yield no assimilation of either obstruents or sonorants in a language. Section 2.3 discusses examples where obstruents but not sonorants are involved in assimilations, while section 2.4 gives examples where sonorants cause or undergo assimilation, leading to violations of the highly ranked STAY 3 and RESIST 3.

In Hungarian the ranking between the RESIST constraints and the STAY constraints is indeterminable: ASSIM is ranked above both STAY 2 and RESIST 2 and below both STAY 3 and RESIST 3. As a result, assimilation from voiceless to voiced (violating RESIST 2) and assimilation from voiced to voiceless (violating STAY 2) both occur. In other languages, ASSIM ranks between the STAY and RESIST constraints of a particular level. If ASSIM ranks above RESIST 2 but below STAY 2, then voiceless consonants will voice but voiced consonants must obey STAY 2 and so do not assimilate to voiceless consonants. I will call assimilation toward a higher value on a scale (such as 1 → 2) *upward* assimilation. In a language with only upward assimilation /pd/ would be realized as *bd*, but /bt/ would be unchanged. If the reverse ranking holds, i.e. ASSIM ranks above STAY 2 but below RESIST 2, then voiced consonants devoice in assimilation but voiceless consonants do not voice. In scalar terms, only *downward* assimilation can occur (e.g. 2 → 1). So /bt/ becomes *pt*, but /pd/ does not change. Upward assimilation is assimilation towards the higher end of the scale, as when obstruents voice (1 →

2) or when obstruents become sonorant (1,2 → 3). Downward assimilation is assimilation towards the lower end of the scale, and happens when obstruents devoice (2 → 1) or when sonorants become obstruents (3 → 2,1). Depending on the relative rankings of STAY, RESIST and ASSIM, only upward, only downward, both upward and downward assimilation, or no assimilation at all may be present in a language. Examples of these rankings of the IV faithfulness constraints with respect to the ASSIM constraint are given in the following sections.

2.2 No Coda-Onset Assimilation: Punjabi

Punjabi (Bhatia 1993) is an example of a language in which codas do not assimilate to following onsets on the IV scale. The lack of assimilation in shown in (22), where (a) gives examples with coda voiceless obstruents, (b) shows voiced obstruents and (c) shows sonorants. For each word the IV scale values of the coda and the following onset are shown in parentheses.

(22) Resistance to assimilation in Punjabi codas

a. Voiceless codas
   na**kd**ii (1.2) 'cash'
   ca**kl**aa (1.3) 'rolling board'[9]
   ve**kʰṇ** aa (1.3) 'to see'

b. Voiced codas
   raa**jp**uut (2.1) 'Rajput' (**j** is a palatal affricate)
   ma**jm**aa (2.3) 'crowd'

c. Sonorant codas
   i**nk**aar (3.1) 'refuse'
   ka**ṇḍ** aa (3.2) 'thorn'

Because the constraints in OT are universal, Punjabi must have the ASSIM constraint, just as the languages in 2.2 do (and so ASSIM might be expected to

[9] Since *kl*- is not a permissable word-initial cluster, the *k* is presumably in coda in *caklaa*.

make itself felt in other contexts). What keeps ASSIM from applying to the examples in (22) is the IV faithfulness constraints. In Hungarian, sonorants were not affected by ASSIM because STAY 3 and RESIST 3 ranked above it. In Punjabi more of the faithfulness constraints outrank ASSIM.

Since sonorants do not undergo assimilation, we know that STAY 3 outranks ASSIM, just as it did in section 2.2. Since the obstruents do not assimilate to the sonorants, we know that RESIST 3 also dominates ASSIM. This is shown in (23).

(23) Ranking motivated by failure to add or lose sonorance
RESIST 3, STAY 3 >> ASSIM

So far, this is like the Hungarian case. The difference lies in the behavior of the obstruents. In *nakdii* 'cash' the voiceless obstruent (IV1) fails to assimilate to the following voiced obstruent. If the *k* did become voiced it would violate the two constraints STAY 1 and RESIST 2. Since *s* does not voice at least one of RESIST 2 and STAY 1 must outrank ASSIM. RESIST 2, being a constraint on IV2, is inherently more highly ranked than STAY 1 which refers to the lower level of IV1. Therefore we know that RESIST 2, at least, must outrank ASSIM.

(24) Ranking motivated by failure to voice obstruents
RESIST 2 >> ASSIM

In the case of voiced obstruents, these keep their IV2 value before IV1. If the *j* in *raajpuut* were to devoice it would violate STAY 2 and RESIST 1. To prohibit the devoicing, at least one of these two constraints must outrank ASSIM. Since STAY 2 is universally more highly ranked that RESIST 1, we know that at least STAY 2 outranks ASSIM. This gives us the ranking in (25).

(25) Ranking motivated by failure to devoice before voiceless
STAY 2 >> ASSIM

Putting together the rankings in the above paragraphs we get the full ranking in (26), where the language-specific ranking of ASSIM is shown in bold.

(26) Ranking of ASSIM in Punjabi

STAY 3, RESIST 3 >> STAY 2, RESIST 2 **>> ASSIM**, STAY 1, RESIST 1

In such a language, the relative rankings of STAY and RESIST are undetermined, since neither is violated. The relative ranking of ASSIM, STAY 1 and RESIST 1 is also undetermined. In order to satisfy ASSIM, codas which do not match the following onsets must change their IV values. In so doing they lose their underlying value and take on a new value. Faithfulness constraints at both values are violated: a STAY constraint for the lost value and a RESIST constraint for the new value. The violation of a faithfulness constraint on IV1 will thus always be accompanied by the violation of a faithfulness constraint on a higher IV value. Because of the inherent ranking of the faithfulness constraints, the faithfulness constraint on IV1 will always be the lower ranked of the two. It only takes one of the two faithfulness constraints ranking above ASSIM to stop the assimilation. The ranking among the remaining ASSIM, STAY 1 and RESIST 1 can therefore not be determined.[10] The ranking in (26) is illustrated in the tableaux in (27).

(27) Lack of Coda Assimilation in Punjabi

a) Voiceless obstruents fail to voice before voiced obstruent

na**kd**ii	RESIST 3	STAY 3	RESIST 2	STAY 2	ASSIM	RESIST 1	STAY 1
√ k . d					*		
g . d			*!				*

[10] A question that could be asked at this point is whether there is any need for STAY 1 and RESIST 1, given that these always rank at the bottom of the faithfulness subhierarchy. I include them for completeness, so that each step on the scale has faithfulness constraints referring to it. Leaving out STAY 1 and RESIST 1 would not change the essential ternarity of the scale, however. Such a move would be like using O, 1, 2 as scale values, rather than 1, 2, 3. Either way, the scale has three values.

b) Voiced obstruents fail to devoice before voiceless obstruents

raa**jp**uut	RESIST 3	STAY 3	RESIST 2	STAY 2	ASSIM	RESIST 1	STAY 1
c . p				*!		*	
√ j . p					*		

c) Sonorants fail to assimilate before obstruents

i**nk**aar	RESIST 3	STAY 3	RESIST 2	STAY 2	ASSIM	RESIST 1	STAY 1
t . k		*!				*	
d . k		*!	*		*		
√ n . k					*		

d) Obstruents fail to assimilate before sonorants

caklaa	RESIST 3	STAY 3	RESIST 2	STAY 2	ASSIM	RESIST 1	STAY 1
√ k . l					*		
g . l			*!		*		*
ŋ . l	*!						*

The Punjabi example shows a ranking of ASSIM with respect to the faithfulness constraints that totally disables ASSIM. If both STAY 2 and RESIST 2 rank above ASSIM, then both STAY 3 and RESIST 3 also rank above ASSIM. In such a case no coda assimilation can take place, because ASSIM must outrank faithfulness constraints at at least two levels to cause assimilations.

2.3 Assimilation of Obstruents (IV1 and IV2)

This section considers cases where ASSIM is ranked highly enough to cause obstruents to assimilate to one another but not highly enough to cause assimilation of sonorants to obstruents or obstruents to sonorants. The languages examined so far have not provided a motivation for the ranking of STAY and RESIST with respect to one another. The section provides examples of languages that do give evidence of a ranking between STAY and RESIST and justify the use of these two separate faithfulness constraint families.

2.3.1 Upward Assimilation Only: Ukrainian

In many dialects of Ukrainian (Zilyns'kyj 1979, Humesky 1980).[11] , voiceless obstruents voice before voiced obstruents, but voiced obstruents retain their voicing before voiceless obstruents. Thus Ukrainin allows upward assimilation without downward assimilation. This has the effect of allowing all IV combinations except IV1+IV2 (voiceless+voiced). (28a) shows voicing of voiceless obstruents before voiced obstruents, while (28b) shows the lack of devoicing in voiced obstruents before voiceless obstruents (data from Humesky, who does not provide glosses).[12]

(28) Upward assimilation in Ukrainian

a) voiceless obstruent voices (IV1 → IV2)
/boro**t**'ba/ [d'.]
/ja**k** ž e/ [g.]
/vo**k**zal/ [g.]

b) voiced obstruent unaffected (IV2 stays IV2)
/š vy**d**ko/ [d.]
/v'i**d**pov'idajte/ [d.]

Although neither Humesky nor Zilyns'kyj gives examples of the behavior of obstruents before sonorants, it is clear that in most dialects obstruents retain their underlying IV specifications before sonorants. Zilyns'kyj states that it is only in certain regions that voiceless consonants are voiced "even before sonorants" (p.151). In some dialects, then, sonorants cause voicing in obstruents, causing IV1 segments to become IV2 even though the assimilation trigger is IV3.

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[11] Some dialects also have downward assimilation.
[12] According to Zilyns'kyj, some dialects have voicing throughout in codas, while others have weakened voicing. This is true in codas word-internally and word-finally.

This process is known as attraction. In this section I focus on the dialects that do not experience attraction. The difference between languages (or dialects) that have attraction and those that do not will be discussed in section 2.5.

The Ukrainian pattern of upward assimilation without downward assimilation illuminates the distinction between the STAY and RESIST constraints. Under the force of ASSIM, IV1 voiceless obstruents voice and become IV2. So the /k/ in /vokzal/ surfaces as *g*. In so doing it violates STAY 1 and RESIST 2. This tells us that in Ukrainian ASSIM outranks both STAY 1 and RESIST 2, since it can cause both to be violated.

(29) Ranking motivated by voicing (IV1 → IV2)

ASSIM >> RESIST 2 >> STAY 1

In Ukrainian, voicing (IV2) may be added to accommodate ASSIM. In other words, RESIST 2 can be violated. The IV2 value may not be lost, however. So the /d/ in /š vy**d**ko/ stays voiced. This means that STAY 2 outranks ASSIM, as in (30).[13]

(30) Ranking motivated by failure of devoicing (IV2 stays IV2)

STAY 2 >> ASSIM

STAY 2 must outrank ASSIM, but ASSIM must outrank RESIST 2. The ranking of STAY 2 above ASSIM ensures that IV2 segments can not be forced by ASSIM to assimilate. Since RESIST 2 is ranked below ASSIM, IV2 segments can be derived to satisfy ASSIM. The IV2 value may be added, but it can not be taken away. This means that the analysis must make a distinction between adding and losing scale values. The separate RESIST and STAY hierarchies reflect this distinction.

The derived IV2 segments may only come from segments that are IV1 in the input, since ASSIM must outrank STAY 1 but not STAY 3, given its ranking

[13] The failure of a voiced obstruent to become voiceless could theoretically be ascribed to the ranking of RESIST 1 above ASSIM. However, since ASSIM outranks RESIST 2 (as in(29)) it must also outrank RESIST 1 and we must look elsewhere for the explanation of the failure of IV2 to become IV1.

between STAY 2 and RESIST 2. Assimilation may proceed with a RESIST 2 (and STAY 1) violation, but not with a STAY 2 (and RESIST 1) violation. The ranking is summarized in (31) with the language-specific aspect of the ranking shown in bold.

(31) STAY 3, RESIST 3 >> **STAY 2 >> ASSIM >> RESIST 2** >>STAY 1, RESIST 1

The tableau in (32) illustrates the Ukrainian ranking, leaving out STAY 3 and RESIST 3 for reasons of space. They are never violated in Ukrainian.

(32) Ukrainian Assimilation

a) Voicing of obstruents before voiced obstruents

vo**k.z**al	STAY 2	ASSIM	RESIST 2	STAY 1	RESIST 1
√ k z → g z			*	*	
k z → k z		*!			

b) Voiced obstruents fail to devoice before voiceless obstruents

š vy**d.k**o	STAY 2	ASSIM	RESIST 2	STAY 1	RESIST 1
√ d k → d k		*			
d k → t k	*!				*

As tableau (32b) shows, ranking STAY 2 above ASSIM prohibits the devoicing of obstruents in order to assimilate to a following voiceless obstruents. The last candidate in the tableau, which attempts this devoicing, fatally violates STAY 2. Because RESIST 2 is ranked below ASSIM, however, obstruents are voiced under assimilation to voiced obstruents. The first candidate in (32a) wins because it has only violated RESIST 2 and STAY 1, while the second candidate fatally violates the higher ranking ASSIM. Tableau (32) demonstrates the distinct effects of STAY 2 (prohibiting loss of IV2) and RESIST 2 (prohibiting addition of

IV2), since ASSIM is ranked between them. RESIST 2 is violable under pressure from ASSIM, but STAY 2 is not.

2.3.2 Downward Assimilation Only: Mekkan Arabic

A language with downward assimilation but not upward assimilation has assimilation to voicelessness only. An example of such a language is Mekkan Arabic. (33) gives examples where (a) illustrates downward assimilation of IV2 to IV1, (b) shows the retention of underlying IV values before voiced obstruents (IV2), and (c) shows the retention of underlying IV values before sonorants (IV3). The examples in (d) show that voicing (IV2) is retained in word-final position (data from Abu-Mansour, 1994).

(32) Downward assimilation in Mekkan Arabic

a) Assimilation of voiced to voiceless (IV2 → IV1)

/ʔa**ǰ** tamaʕ/	[š]	'met with'
/ʔa**ḍ** fa/	[ṭ]	'added to'

b) Retention of underlying values before voiced (IV1 and IV2 unchanged before IV2)

/ʔa**z**dahar/	[z]	'he prospered'
/ma**d**baɦa/	[d]	'massacre'
/ma**t**ǰ ar/	[t]	'shop'
/xu**ṭ** bah/	[ṭ]	'engagement'
/ʔa**k**bar/	[k]	'older'

c) Retention of underlying values before sonorants (IV1 and IV2 unchanges before IV3)

/ʔi**b**nu/	[b]	'his son'
/ǰ i**s**mu/	[s]	'his body'
/ʔa**ṣ** lu/	[ṣ]	'his origin'

d) Retention of voicing (IV2) finally

/ǰ a**dd**/	[dd]	'grandfather'
/baʕ**ḍ** /	[d]	'some'

The examples in (b), (c) and (d), where voicing contrasts in obstruents are retained before IV2 (voiced obstruents) IV3 (sonorants) and pause, emphasize that it is only before voiceless obstruents(IV1) that voiced obstruents lose their voicing. The retention of voiced obstruents in most contexts shows that the devoicing before voiceless obstruents can not be attributed to a general process of coda neutralization.

In the ternary scales model the Mekkan voicing facts can be analyzed as downward assimilation to voicelessness unaccompanied by upward assimilation or by coda neutralization. In Mekkan Arabic coda voiced obstruents assimilate to following voiceless onsets. So the *ḍ* in /ʔa**ḍ** fa/ 'added to' becomes *ṭ*. In doing so it violates STAY 2 and RESIST 1. This tells us that ASSIM must outrank both STAY 2 and RESIST 1, as in (34).

(34) Ranking motivated by devoicing assimilation in Mekkan
ASSIM >> STAY 2 >> RESIST 1

By the ranking in (34), voicing (IV2) may be lost to accommodate ASSIM. Voicing may not be added, however. The k in /ʔa**k**bar/ remains *k* and does not become *g*. This means that ASSIM is not highly enough ranked to force upward assimilation. ASSIM still calls for IV identity in these cases, but it is outranked and therefore impotent. Since voicing can not be added, this means that RESIST 2 must outrank ASSIM. This is shown in (35).

(35) Ranking motivated by lack of voicing assimilation in Mekkan
RESIST 2 >> ASSIM

The full ranking responsible for IV processes in a language like Mekkan Arabic is shown in (36). In this language ASSIM is crucially ranked between RESIST 2 and STAY 2. As in Ukrainian, this demonstrates the necessity of separate STAY and RESIST constraints, since one is violable under the force of ASSIM while the other is not. In Ukrainian STAY 2 dominated RESIST 2 (with ASSIM in the middle), while in Mekkan Arabic RESIST 2 dominates STAY 2 (with ASSIM in between).

(36) Full ranking in Mekkan Arabic
RESIST 3, STAY 3 >> **RESIST 2 >> ASSIM >> STAY 2** >> RESIST 1, STAY 1

By the ordering in (36), ASSIM can not induce a RESIST 2 (or RESIST 3) violation, so upward assimilation and attraction are impossible. The ranking of STAY 2 (and RESIST 1) below ASSIM allows downward assimilation. The tableaux in (37) illustrate the ranking responsible for the Mekkan pattern of downward assimilation only, again leaving out STAY 3 and RESIST 3 since they are never violated.

(37) Mekkan Arabic Assimilation
a) Voiced obstruents devoice before voiceless obstruents

ʔa**ḍ .f**a	RESIST 2	ASSIM	STAY 2	RESIST 1	STAY 1
√ ḍ f → ṭ f			*	*	
ḍ f → ḍ f		*!			

b) Voiceless obstruents fail to voice before voiced obstruents

ʔa**k.b**ar	RESIST 2	ASSIM	STAY 2	RESIST 1	STAY 1
√ k b → k b		*			
k b → g b	*!				*

As tableau (37a) shows, the faithful second candidate for /ʔa**ḍ .f**a/ fatally violates ASSIM. The first candidate wins because it satisfies ASSIM despite violation of the lower ranked STAY 2 and RESIST 1. So the candidate which assimilates downward from voiced obstruent to voiceless obstruent, yielding *ʔaṭ fa*, is the best. In (37b), in /ʔakbar/ the ASSIM constraint can not be satisfied. The attempt of the second candidate to assimilate violates the higher ranked RESIST 2.

When ASSIM can not be satisfied, the best candidate is faithful to the underlying IV value.

While devoicing of obstruents before voiceless obstruents is common, the precise pattern shown by Mekkan Arabic is not, since many languages which have assimilation on the IV scale also have neutralization of voiced obstruents (IV2) in codas. A language with the same ASSIM ranking as Mekkan Arabic could have a higher ranked neutralization constraint which would neutralize the obstruents in other coda contexts as well.[14] Since neutralization of IV2 to IV1 also targets codas, it is not always obvious which devoicing is due to assimilation and which is due to neutralization. The Mekkan Arabic examples shows that neutralization and assimilation to IV1 can be distinguished from each other. In Mekkan only the coda obstruents which are followed by voiceless obstruents (IV1) devoice. These obstruents are targets for assimilation to IV1. Other coda IV2 obstruents would be targets for neutralization. These other coda obstruents do not devoice, as examples like *ǰ a**dd*** 'grandfather' and *ʔi**b**nu* 'his son' demonstrate. So the only devoicing that occurs is that caused by assimilation, so it is assimilation not neutralization that is at work in Mekkan Arabic. Neutralization is not at work in Mekkan Arabic since the neutralization constraint is low ranked in Mekkan. The interaction of neutralization with assimilation is discussed more fully in Chapter 4.

In binary [voice] theories Mekkan Arabic would be analyzed as having assimilation of [–voice] without assimilation to [+voice]. Such binary theories have been fairly criticized for failing to explain why neutralization seeks out [–voice]. If both [+voice] and [–voice] are defined on equal grounds then the selection of [–voice] as the neutral value is arbitrary. Privative theories of voicing

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[14] As shown in Chapter 4, the neutralization constraint will only be deactivated if it ranks below STAY 2.

(e.g. Itô & Mester 1986, Lombardi 1991) describe voicelessness as the lack of a [voice] specification, making neutralization simply the loss of the [voice] node. In privative [voice] theories assimilation to voicelessness is impossible, so a language such as Mekkan Arabic can not be analyzed as having assimilation to voicelessness. Mekkan Arabic must therefore be analyzed as a neutralizing language. Mekkan Arabic lacks most of the features of a neutralizing language, however. It does not devoice word-final codas, and it does not devoice codas before voiced or even sonorant onsets. In order to analyze Mekkan Arabic as a neutralizing language, therefore, a privative theory must make some additional stipulations.

To account for the lack of neutralization word-finally Lombardi (1991) proposes a principle of word-final exceptionality. By this principle the [voice] feature can be licensed in word-final position even though it is not normally licensed in codas. The lack of neutralization before voiced and sonorant segments is handled by Lombardi and by Abu-Mansour (1994) with a principle of 'fusion', by which the [voice] feature of the obstruent is fused with that of a following voiced obstruent or sonorant. The otherwise unlicensed [voice] feature is then immune to neutralization since the feature is doubly linked to a segment in which it is licensed. In an ordered derivation, this means that the Mekkan Arabic neutralization occurs late in the derivation, after the default fill-in of [voice] in sonorants has taken place, since the obstruent's [voice] feature must be allowed to fuse with the sonorant's [voice] feature.

The ternary scales theory can avoid the extra stipulations of the privative [voice] theories since it allows straightforward assimilation to voicelessness (IV1). In so doing it also avoids the pitfalls of the binary [voice] theory that the privative theories have sought to overcome. The selection of IV1 as the result of neutralization does not require IV1 to be unspecified. Rather, it results from the universal low ranking of IV1 faithfulness, as will be demonstrated in Chapter 4. In the ternary model, each IV value can be fully specified, and the rankings of assimilation and neutralization constraints with respect to the faithfulness hierarchies determine when they are active in assimilation and neutralization. Because faithfulness to IV1 is low ranked, this value is easily added and easily lost. Because faithfulness to IV3 is highly ranked, IV3 is very hard to add or lose. Neither value is unspecified, and both find their place on the ternary scale. Unlike the privative theories, the ternary scales framework has no need to invoke the concepts of 'final exceptionality', 'fusion' and double linking. Instead, the Mekkan Arabic facts are straightforwardly accounted for by a ranking of the assimilation and faithfulness constraints in the absence of neutralization.

2.3.3 Upward and Downward Assimilation: Sudanese Arabic

In Sudanese Arabic coda obstruents agree with following onset obstruents in voicing. Voiced obstruents devoice before voiceless obstruents, and voiceless obstruents voice before voiced obstruents. Sonorants neither trigger nor undergo assimilation. In terms of the IV scale, IV1 assimilates to IV2 and IV2 assimilates to IV1, while IV3 is unaffected. (38a) shows the full IV contrasts in word-final coda consonants, while (38b) shows the assimilation of voiceless obstruents to voiced obstruents, (38c) shows assimilation of voiced obstruents to voiceless obstruents and (38d) shows the retention of underlying IV values before sonorants (Hamid 1984, Abu-Mansour 1994).[15] Though Hamid does not give examples of sonorants before obstruents, he states (p133f) that voicing assimilation only occurs between obstruents, so sonorants must be immune to assimilation.

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[15] In addition to the assimilations involving oral obstruents shown in (38), pharyngeal consonants in Sudanese Arabic trigger voicing assimilation but do not undergo such assimilation.

(38) Assimilation of obstruents in Sudanese Arabic

a. Full IV constrasts in isolation

sama**k**	'fish'	(IV1)
saba**b**	'reason'	(IV2)
gala**m**	'pen'	(IV3)

b. Obstruents are voiceless before voiceless (IV1, IV2 → IV1)

ʔaṭ faal 'children', cf. ṭ ifil 'child'

ya**p**sim 'to smile, imperfect.', cf. **b**asam 'to smile, perfect'

ʔa**k**saam 'divisions', cf. **g**isim 'division'

c. Obstruents are voiced before voiced (IV1, IV2 → IV2)

ʔa**g**bar 'bigger/older', cf. **k**abiir 'big/old'

ʔa**z**baab 'reasons', cf. **s**abab 'reason'

ʔa**b**ġ aal 'mules', cf. **b**aġ al 'mule'

d. IV constrasts preserved before sonorants (IV1, IV2 stay IV1, IV2)

ʔa**s**maak 'fish,pl.'

ʔa**g**laam 'pens'

The Sudanese Arabic facts are parallel to the Hungarian facts discussed in detail in Section 2.1.1. As in Hungarian, obstruents assimilate to each other and sonorants are unaffected. The rankings are therefore the same in Sudanese Arabic as in Hungarian, given in (39).

(39) Ranking motivated by upward and downward assimilation

STAY 3, RESIST 3 >> **ASSIM** >> STAY 2, RESIST 2 >> STAY 1, RESIST 1

The ranking in (39) does not need to be remotivated here, as it has been discussed for Hungarian in section 2.1.1. I include Sudanese Arabic here briefly, however, to be faithful to the pattern of gradually ascending ASSIM. In Punjabi, ASSIM was ranked below both STAY 2 and RESIST 2. In Ukrainian it ranked above RESIST 2, but below STAY 2. In Mekkan Arabic it ranked above STAY 2, but not RESIST 2. Now, in Hungarian and Sudanese Arabic, ASSIM ranks above both RESIST 2 and STAY 2.

Due to the ranking in (39), assimilation occurs to both voicing (IV2) and voicelessness (IV1). By contrast, a theory which uses privative [voice] (such as Lombardi 1991, Abu-Mansour 1994) can not analyze the voicing agreement in Sudanese Arabic obstruents as assimilation to both [+voice] and [–voice]. It must therefore be analyzed as a combination of spreading, neutralization, and final exceptionality. The spreading of the [voice] node accounts for the voicing of voiceless obstruents before voiced obstruents. Neutralization, i.e. loss of the [voice] node, is meant to account for the voicelessness of obstruents before voiceless obstruents. Final exceptionality, which allows [voice] word-finally, must be called on to stop neutralization from applying to final obstruents, since final obstruents contrast in voicing.

As seen for the Mekkan Arabic case, the present theory does away with any need to invoke final exceptionality. This is because assimilation to voicelessness is permitted in this theory, since assimilation can operate on any IV specification, including IV1. Neutralization of voiced obstruents is accounted for separately (see Chapter 4) without requiring voiceless obstruents to lack an IV specification.

2.4 Assimilations Involving Sonorants

In 2.2 I considered cases where ASSIM is not ranked highly enough with respect to the faithfulness constraints to allow any IV assimilations. 2.3 considered cases where ASSIM is ranked highly enough to cause at least some assimilation in obstruents (IV1 and IV2). I turn now to cases where ASSIM is ranked highly enough to cause assimilations involving sonorants (IV3). Such cases will be rarer than the others, due to the inherent high ranking of the FAITH 3 constraints.

2.4.1 Assimilation to Sonorants: Korean, Catalan

In Korean, obstruent codas assimilate to following sonorants. In coda position all obstruents will otherwise be voiceless stops, while the following sonorant will be a nasal, but may be underlyingly a liquid. The Korean assimilation is shown in (40) (from Kim-Renaud (1986), S-A Jun (1993) and J. Jun, p.c.).

(40) Korean obstruent-sonorant assimilation
/mə**kn**a/ [ŋ.n] 'Does he eat?'
/sa**pn**al/ [m.n] 'blade of a shovel'
/i hopa**k m**aš innɯndɛ/ [ŋ.m] 'This pumpkin is delicious.'

In order for Korean voiceless obstruents to become nasal sonorants, an IV3 value must be added. Adding an IV3 value violates RESIST 3, so ASSIM must be ranked above RESIST 3, as in (41).

(41) Ranking motivated by assimilation to sonorants
ASSIM >> RESIST 3

This is the first case considered so far where ASSIM has outranked a faithfulness constraint on IV3. By the ranking of ASSIM over RESIST 3 (and therefore also the low-ranked STAY 1) voiceless obstruents can leave their IV1 value and take on an IV3 value. Coda sonorants do not assimilate to following obstruents, however. In other words, an IV3 value can be added, but it can not be lost. The failure of coda sonorants to assimilate implies that STAY 3 still outranks ASSIM, as in (42).

(42) Ranking motivated by failure of sonorants to assimilate
STAY 3 >> ASSIM

The full set of constraint rankings in Korean are given in (43).

(43) Full ranking in Korean
STAY 3 >> ASSIM >> RESIST 3 >> STAY 2 >> RESIST 2 >> STAY 1 >> RESIST 1

By the ranking in (43) sonorants can be created through assimilation, but they can not be lost through assimilation. Tableau (44) shows these constraints in action, with (44a) showing the assimilation of voiceless obstruents and (44b) showing the lack of assimilation in coda sonorants. STAY 2 is left out for reasons on space. There are no underlyingly voiced obstruents in Korean.[16]

(44) Korean Assimilation

(a) Assimilation of coda voiceless obstruents

/…k n…/	STAY 3	ASSIM	RESIST 3	RESIST 2	STAY 1	RESIST 1
k. n		*!				
g. n		*!		*	*	
√ ŋ. n			*		*	

(b) No assimilation of coda sonorants

/…n t…/	STAY 3	ASSIM	RESIST 3	RESIST 2	STAY 1	RESIST 1
√ n. t		*				
d. t	*!	*		*		
t. t	*!					*

The ranking of ASSIM above RESIST 3 in tableau (44) allows obstruents to assimilate all the way to sonorants (IV3). So underlying /k/ in /məkna/ 'does he eat?' becomes ŋ. The ranking of STAY 3 above ASSIM, however, prohibits sonorants from assimilating to obstruents. Underlying /n/ surfaces as *n* even before a voiceless obstruent onset. IV3 may therefore be gained but not lost under the force of ASSIM in Korean.

Catalan also has assimilation of obstruents to sonorants, but the assimilation is subject to certain conditions (Wheeler 1979). In rapid speech stops are assimilated to nasals. This is shown in (45a). Coronal stops are also assimilated to laterals, as shown in (45b). Examples are given in Catalan orthography, which represents the non-assimilated form of the relevant

[16] Not shown in the tableau is the IV attraction of onset lax stops to preceding sonorants (vowel or consonant). Thus the output of /nt/ would actually be *nd*. The traditional description of this situation is that lax stops voice between sonorants.

segments. Transcriptions of the assimilating coda and following onset are given in brackets.

(45) Assimilations to sonorants in Catalan

a. Assimilation of stops to nasals
fe**t n**ou [n.n] 'made new'
to**t m**illor [m.m] 'all better'
a**dm**etre [m.m] 'to admit'
a**bn**egació [m.n] 'abnegation'
pra**gm**àtic [ŋ.m] 'pragmatic'

b. Assimilation of coronals stops to laterals
aques**t ll**um [ʎ.ʎ] 'this lamp'
di**t ll**arg [ʎ.ʎ] 'long finger'
fe**t l**ògic [l.l] 'logical fact'

The assimilations in (45a) (except in homorganic cases like *fet nou* 'made new') only occur in rapid speech. In rapid speech coronals also undergo place assimilation before labials as seen by the geminate *m* pronunciation of *a**dm**etre* 'to admit' and *to**t m**illor* 'all better'. The assimilation of *g* to ŋ, such as in *prà**g**matic*, only occurs in rapid speech within words. In (45b) the coronal stops assimilate to (coronal) laterals, with palatalizing assimilation occuring as well. Non-coronal stops do not become sonorants before laterals.

As shown in (45), assimilation to non-homorganic IV3 sonorants occurs only in fast speech environments in Catalan. Another restriction on the assimilation is that it involves segments of the same stricture, i.e. stops.[17] When the segments are of different stricture attraction occurs instead of outright assimilation. That is, voiceless obstruents voice (IV1 → IV2), but they do not go all the way to the sonorant's IV3 value. (46a) shows slow speech attraction

[17] Laterals behave as stops with respect to coronals in Catalan, but not with respect to other places (Mascaró 1984).

between segments of the same stricture and (46b) shows attraction between segments of different strictures.

(46) Attraction in Catalan (IV1 → IV2 / __ IV3)

a. Slow speech attraction
ca**p n**ovetat [b.n] 'no change'
to**t m**illor [d.m] 'all better'

b. Different stricture attraction
ca**s n**otable [z.n] 'notable case'
sa**p r**iure [b.r] 'knows how to laugh'

When full assimilation fails in Catalan, attraction takes place instead. The difference between slow speech and fast speech is outlined in (47). (Assimilation and attraction in Sanskrit external sandhi behave similarly to Catalan fast speech (Whitney 1889).)

(47) Fast and slow speech assimilations in Catalan

Fast	**Slow**	
Assimilation	Assimilation	Homorganic Same Stricture
Assimilation	Attraction	Heterorganic Same Stricture
Attraction	Attraction	Different Stricture

Full assimilation fails not only in slow speech where the target and trigger are heterorganic, but also when the target and trigger of the assimilation have different stricture. This is a typical constraint on similarity between assimilation target and trigger, such as Selkirk's (1991) Homogeneous Stricture Linking constraint. Here I will call the constraint 'Sonorant Stricture'.

(48) Sonorant Stricture: Adjacent sonorants have identical stricture.[18]

[18] Just as ASSIM is defined as applying to any adjacent segments, with positional faithfulness determining the scope of operation, so Sonorant Stricture is defined over any adjacent sonorants. Again, I leave open on what tiers adjacency is defined.

Sonorant Stricture disallows full assimilation where it would create a sequence of sonorants with different strictures. Since underlying sequences of sonorants with different stricture surface unscathed, I conclude that STAY 3 >> Sonorant Stricture. There is a similar constraint (which one could call 'Sonorant Place') that disallows full assimilation where it would create heterorganic sonorant sequences. This constraint is active in slow speech, so that sequences such as *nm* and *mn* are not created but *dm* and *bn* are (as in (46a)). In fast speech this constraint is dominated and the ŋ*m* and *mn* sequences of (45a) are created. Since the Sonorant Place constraint is not obeyed in fast speech, I leave it aside for the present purposes.

I consider here the fast speech rankings, since they allow the creation of sonorants relevant to this section. In order to allow any creation of sonorants by assimilation, ASSIM must outrank RESIST 3, as shown in (49).

(49) Ranking motivated by assimilation to sonorants (fast speech)

ASSIM >> RESIST 3.

The assimilation does not create sonorants if the resulting output sonorants would violate Sonorant Stricture. This means that Sonorant Stricture is ranked above ASSIM, as in (50).

(50) Ranking motivated by non-assimilation to dissimilar sonorants

Sonorant Stricture >> ASSIM

Although ASSIM can force creation of sonorants, it can not force sonorants to become obstruents. In other words, upwards assimilation of obstruents to sonorants occurs, but not downward assimilation from sonorants to obstruents. This means that STAY 3 must outrank ASSIM, since ASSIM can not force violation of STAY 3, as shown in (51).

(51) Ranking motivated by failure of sonorants to assimilate

STAY 3 >> ASSIM

The full set of rankings for Catalan fast speech is given in (52).

(52) Full Catalan fast speech ranking
STAY 3 >> Sonorant Stricture >> ASSIM >> RESIST 3 >> STAY 2 >> RESIST 2 >> STAY 2 >> RESIST 1

By the ranking in (52) voiceless and voiced obstruents can assimilate to sonorants with similar stricture, but sonorants may not assimilate to obstruents.

The ranking of ASSIM above RESIST 3 implies that ASSIM is also ranked above STAY 2 and RESIST 2, causing voicing assimilations among obstruents. Unlike Korean, which does not have a voicing distinction in obstruents, Catalan has both voiceless and voiced obstruents and has voicing assimilation among obstruents, as the ranking in (52) predicts (the assimilation among obstruents occurs even in slow speech). This is shown in (53).

(53) Assimilation among obstruents in Catalan
llar**g d**e cames [g.d] 'long legged'
llar**g c**amí [k.k] 'long road'
bu**f c**alent [f.k] 'warm puff of air'
bu**f d**'aire [v.ð] 'puff of air'
é**s f**als [s.f] 'it is false'
é**s v**eritat [z.β] 'it is true'

Voiceless obstruents (IV1) voice before voiced obstruents (IV2), violating RESIST 2 and STAY 1. Similarly, voiced obstruents devoice before voiceless obstruents, violating STAY 2 and RESIST 1. From the ranking in (52) such violations under the force of ASSIM are expected, since ASSIM outranks STAY 1 and RESIST 1, STAY 2 and RESIST 2, and even RESIST 3 (with some differences in application between slow and fast speech).

The fast speech ranking is demonstrated in tableau (54). In each tableau in (54) a portion of the faithfulness hierarchy is left out for reasons of space. The assimilation of obstruents in (53) is not included: the upward and downward assimilation among obstruents proceeds exactly as in Hungarian and Sudanese

Arabic in tableau (20).[19] The attraction of obstruents toward sonorants in cases of different stricture is shown in (59b). For the moment attraction (IV1 → IV2/ __ IV3) will be shown as violating ASSIM once, while non-attraction (IV1 stays IV1) will be shown as violating ASSIM twice. The proper description of attraction will be discussed in Section 2.5. The failure of sonorants to assimilate to obstruents is shown in (54c).

(54) Catalan Assimilations

(a) Assimilation of obstruents to sonorants

/…t. n…/	STAY 3	Sonorant Stricture	ASSIM	RESIST 3	RESIST 2	STAY 1
t. n			*!			
d. n			*!		*	*
√ n. n				*		*

(b) Attraction of obstruents to non-similar sonorants

/…s. n…/	STAY 3	Sonorant Stricture	ASSIM	RESIST 3	RESIST 2	STAY 1
s. n			**!			
√ z. n			*		*	*
r. n		*!		*		*

(c) Non-assimilation of sonorants to obstruents.

/…m.t…/	STAY 3	Sonorant Stricture	ASSIM	RESIST 3	RESIST 2	RESIST 1
m.t			*			
b.t	*!		*		*	
p.t	*!					*

Tableau (54a) shows that obstruent *t* (as in *fet nou* [n] 'made new') can become a nasal sonorant under the force of ASSIM, given that *t* and *n* have the

[19] A difference between Catalan and Hungarian or Sudanese Arabic (irrelevant to the ranking discussed here) is that Catalan has coda neutralization of voiced obstruents. The neutralization constraint (discussed in Chapter 4) is ranked more highly in Catalan.

same stricture. (54b) shows that in a case like /sn/ where the target and trigger do not have the same stricture, the Sonorant Stricture constraint disallows full assimilation. Attraction can occur instead, yielding *zn*. In (54c) a sonorant like *m* can not undergo assimilation on the IV scale. STAY 3 is too highly ranked to allow it to lose it's IV3 value.

In all the languages examined so far STAY 3 has dominated ASSIM. The next section turns to a case where ASSIM does outrank STAY 3.

2.4.2 Assimilation of Sonorants: Kaingang

A language in which sonorants assimilate to obstruents is Kaingang, a language of Brazil. The loss of sonorance (IV3) means that ASSIM outranks STAY 3 in Kaingang. Kaingang has the following consonant phonemes (Henry, 1948).

(55) Kaingang consonants

p		t	č	k	
^{m}b		^{n}d	$^{n}\check{z}$	$^{\text{ŋ}}g$	
m	ɱ	n	ñ	ŋ	
		l			
	v	θ[20]	y		h

The prenasalized stops pattern both as obstruents and as nasals. I analyze them as contour segments, having the value IV2 as well as the value IV3. This follows Anderson (1976b) who describes prenasalized segments as [+sonorant] and [–sonorant].

Underlyingly all Kaingang syllables end in a vowel, or nasal or nasalized consonant (other than ɱ).[21] This means that all coda consonants must be

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[20] Henry (1948) actually transcribes θ as ð, stating that phonetically it begins voiceless and continues voiced. However, it patterns with the other voiceless obstruents, so I have assigned it to θ.

[21] I use Henry's pronouncement on underlying values here. Actually, such restrictions on the input are not possible within Optimality Theory. Rather, the constraint hierarchy of Kaingang will ensure that output codas are nasal except where forced to be otherwise by the ASSIM constraint. Thus ASSIM outranks the Coda Condition which states that codas must be nasal. The Coda Condition must outrank RESIST 3 and RESIST [nasal] in order to turn any underlying non-

[+nasal]. Before a voiceless obstruent, however, the nasal or nasalized stop (with the exception of ^{n}ž which never assimilates to anything) assimilates to the voicelessness (and orality) of the obstruent. This results in the changes in (56) (Henry does not give examples of particular forms).[22]

(56) Kaingang assimilation

m → p ^{m}b[23] → p n → t ^{n}d → t ŋ → k ^{ŋ}g → k	}	__ voiceless (IV1), with homorganic degemination

As (56) shows, Kaingang coda consonants assimilate to following onsets even at the cost of losing their sonority. In losing their sonority these coda consonants violate STAY 3. The Kaingang assimilations require an ordering of ASSIM above STAY 3 (and thus also above STAY 2) in order to force the violation of STAY 3. The relevant rankings are shown in (57).

(57) Ranking of ASSIM in Kaingang

ASSIM >> STAY 3 >> RESIST 2, STAY 2 >> RESIST 1, STAY 1

The ranking of RESIST 3 is not given in (62). The exact ranking of RESIST 3 can not be determined by looking at the coda assimilations, since the assimilating segments already have IV3 specifications.[24]

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nasal into a nasal sonorant.

[22] Wiesemann (1972) offers a rather different description of Kaingang, perhaps partly because of dialect differences. The difference relevant here is that in her version of the consonant inventory the prenasalized stops are allophones of the nasals, with the presence or absence of nasalized vowels determining whether the nasal or the prenasal shows up. Nevertheless, her description agrees with Henry's in stating that nasals become voiceless stops before voiceless consonants, although she too fails to give examples.

[23] The nasalized stops ^{m}b etc. are pronounced ^{b}m in codas.

[24] But on the basis of the Coda Condition discussed in footnote 21, the ranking of RESIST 3 below ASSIM can be established, since ASSIM must outrank the Coda Condition, which outranks RESIST 3.

By the ranking in (57) a coda nasal (IV3) or prenasalized stop (IV2-3) will assimilate to a voiceless segment under the force of ASSIM, even when this means violating the high-ranking STAY 3. Thus an *m* would become *p* before a *t*, violating STAY 3 and the low-ranked RESIST 1. Similarly ^{m}b would become *p* before *t*, violating STAY 3 and STAY 2, as well as RESIST 1. The rankings are illustrated in the tableaux in (58), with the irrelevant parts of the faithfulness subhierarchy left out.

(58) Kaingang Assimilations

a) Assimilation of Sonorant Nasal to Voiceless Obstruent

/ m.t.../	ASSIM	STAY 3	RESIST 2	STAY 2	RESIST 1
√ p . t		*			*
^{b}m . t	*!		*		
m . t	*!				

b) Assimilation of Prenasalized Stop to Voiceless Obstruent

/...^{m}b.t.../	ASSIM	STAY 3	RESIST 2	STAY 2	RESIST 1
√ p . t		*		*	*
^{b}m . t	*!				

In both tableaux the winner is the unfaithful candidate that has fully assimilated to the voiceless (IV1) specification, obeying the top-ranked ASSIM. In (58b) the winning candidate violates both STAY 3 and STAY 2 in order to satisfy ASSIM.

Kaingang and languages such as Catalan and Korean demonstrate that STAY 3 and RESIST 3, although universally high ranking, are not inviolable. ASSIM can sometimes rank high enough to cause assimilation to or from sonorants.

2.5 Summary of Rankings

The preceding sections have given examples illustrating the ranking of assimilation constraints with respect to the subhierarchy of constraints on faithfulness to the IV scale. The subhierarchy universally ranks faithfulness to a given scale value higher than faithfulness to a lower scale value, so that FAITH 3 >> FAITH 2 >> FAITH 1. The FAITH constraints consist of the subparts STAY and RESIST which can be independently ranked in specific languages. This means that the ASSIM constraint may have any of the rankings indicated by numbers 1 to 10 in (59). On the top line I give rankings where RESIST outranks STAY. On the middle row are the cases where ASSIM ranks above (or below) both RESIST and STAY at a certain level and so the ranking between STAY and RESIST is indeterminable. On the bottom row I give the rankings of ASSIM in cases where STAY outranks RESIST.

(59) Possible rankings of ASSIM

RES'T 3 >> **2** >> STAY 3 >> RES'T 2 >> **5** >> STAY 2 >> RES'T 1 >> **8** >> STAY 1

1 **4** **7** **10**

STAY 3 >> **3** >> RES'T 3 >> STAY 2 >> **6** >> RES'T 2 >> STAY 1 >> **9** >> RES'T 1

The chart in (60) shows how these rankings are exemplified in the languages discussed above. In cases where the ASSIM constraint ranks above both the FAITH constraints of one level and below both the FAITH constraints of the next level (if any) then the ranking of STAY and RESIST is undetermined. In order for the ASSIM constraint to have any effect it must at least outrank the lowest FAITH 2 constraint. The reason for this is that to force unfaithfulness to one scale level it must be causing assimilation to another scale level and so must dominate faithfulness constraints on at least two levels. This is why there are several low rankings of ASSIM that all lead to the result of no assimilation.

(60) Results of Ranking ASSIM versus the Faithfulness Constraints

Ranking	Result	Language
7, 8, 9, 10	No IV assimilation	Punjabi
6	Upward Assimilation of Obstruents only	Ukrainian
5	Downward Assimilation of Obstruents only	Mekkan Arabic
4	Downward and Upward Assimilation of Obstruents	Hungarian, Sudanese Arabic
3	Assimilation of Obstruents to Obstruents and Sonorants	Korean, Catalan
2	Assimilation of Sonorants and Obstruents to Obstruents	Kaingang
1	Assimilation of Obstruents to Obstruents and Sonorants, and Assimilation of Sonorants to Obstruents	(Kaingang)[25]

2.6 The Nature of Assimilation: Attracting and Non-attracting Languages

The preceding sections have discussed the relative ranking of ASSIM constraint with the scalar faithfulness constraints, and the ranking of faithfulness constraints among themselves. This section turns to the question of the nature of the ASSIM constraint and how to account for the difference between languages that have scalar attraction (IV1 → IV2/ __ IV3) and those that do not (IV1

[25] Kaingang should have this ranking, given the ranking of the Coda Condition discussed in footnotes 23 and 20, but because non-nasals are not allowed to surface finally all we can tell from the assimilation facts is that ASSIM ranks at least as high as 2.

remains IV1 before IV3, but IV1 → IV2/ __ IV2). The general form of the assimilation constraint is given in (61), repeated from (8).

(61) Assimilation constraint
ASSIM: The output {scale} value of adjacent segments must be identical.

As stated, the ASSIM constraint is either fully satisfied (the output values of the two segments are identical) or fully violated (the output values of the two segments are not identical). The consequence of this is that a segment will not change its value to satisfy ASSIM unless it assimilates fully to the triggering segment. If, due to the high ranking of RESIST 3, an obstruent cannot assimilate fully to a sonorant, it will not undergo attraction. This is illustrated in (62) for a non-attracting language such as Hungarian, where the /p/ in *napnyugta* 'sunset' remains voiceless before the /n/.

(62) Non-attraction in Hungarian under ASSIM definition in (66)

/…p . n…/	RESIST 3	ASSIM	RESIST 2
√ p . n		*	
b . n		*	*!
m . n	*!		

In (62), the attempt in the second candidate of the /p/ to undergo attraction and output as *b* is squelched. The *b* does not satisfy ASSIM, since it has a different IV value from the following *n*. Full assimilation to *m* in the third candidate violates the higher-ranked RESIST 3. There is no choice but to violate ASSIM, as in the first candidate, which is the real output.

In languages such as Catalan, however, attraction takes place when full assimilation can not. This was shown in section 2.4.1. In Catalan attraction occurs in cases of differing stricture, while full assimilation to sonorants occurs in other cases (and Sanskrit external sandhi behaves similarly (Whitney 1889)). Thus attraction occurs when full assimilation is prohibited by constraints such as

Sonorant Stricture. Some languages have attraction apart from any full assimilation to sonorants. In other words, assimilation to sonorants is ruled out due to the ranking of RESIST 3 over ASSIM, but attraction (violating RESIST 2) still occurs. This is the case in certain dialects of Ukrainian: voiceless obstruents voice before both voiced obstruents and sonorants (Zilyns'kyj 1979, who does not provide examples). Attraction also occurs in the Krakow dialect of Polish.

In Krakow Polish, word-initial sonorants (vowels and consonants) trigger attraction in a preceding obstruent, as in (63), where (a) shows voicing of an underlyingly voiceless obstruent, (b) shows retention of voicing in an underlyingly voiced obstruent, which would be neutralized to voiceless before a pause, and (c) shows the ordinary assimilation of obstruents before obstruents (Bethin, 1984).

(63) Attraction in Krakow Polish

a) Voicing of voiceless obstruents

bra**t** rodzony	[d]	'own brother'
ja**k** nigdy	[g]	'as never'
cza**s** odjeż dż ać	[z]	'time to go'

b) Retention of voicing in voiced obstruents

sa sia**d** radzi	[d]	'neighbor advises'
rozmó**w** ostatnich	[v]	'of last conversations'
zró**b** inwentarz	[b]	'do inventory!'

c) Assimilation of obstruents to obstruents

wó**z** Tomka	[s]	'Tom's wagon'
zró**b** to	[p]	'do it!'
jedna**k** był o	[g]	'it was anyway'
tamty**ch** ze bów	[ɣ]	'those teeth, gen. pl.'

Word internally, the obstruents in (a) and (b) would be in onset position, since they are followed by a sonorant (consonant or vowel). In word final position, however, they are in codas, and are subject to the ASSIM constraint.[26] The coda status of these consonants (even those followed by vowels) is attested to by the fact that in Warsaw Polish, where attraction does not occur, the voiced word-final obstruents in (63b) undergo neutralization.

In these cases of attraction, if a voiceless obstruent can not assimilate fully to a sonorant (due to high ranking of RESIST 3 or Sonorant Stricture) it will become voiced, moving closer on the IV scale to the assimilation trigger. Languages such as these appear at first to require a definition of ASSIM that will allow segments undergoing attraction to partially satisfy ASSIM, or at least to violate it less than segments which do not move at all on the scale. Such an ASSIM would be gradiently violable, and a segment would receive one violation for each step on the scale by which it fails to assimilate to its trigger. The effects of such a gradient constraint (abbreviated ASSIM(G)) is shown in tableau (64) for a language such as Krakow Polish where ASSIM is dominated by RESIST 3. In a phrase such as *ja**k** nigdy* 'as never' the *k* can not become ŋ due to high-ranking RESIST 3, but it approaches the trigger *n*'s IV3 value.

(64) Attraction in Krakow Polish, using gradient ASSIM

/…k . n…/	RESIST 3	ASSIM(G)	RESIST 2
k . n		**!	
√ g . n		*	*
m . n	*!		

In tableau (64) the fully assimilated candidate (shown last) is discarded on the same grounds as in Hungarian: it violates the high-ranking RESIST 3. The faithful candidate (shown first) incurs two violations of the gradient ASSIM, the

[26] Since vowels trigger the attraction, apparently syllable nuclei as well as syllable onsets can function as adjacent segments for the ASSIM constraint. This is rarely relevant, however, since word-internally a consonant followed by a vowel is always an onset, not a coda.

second of which is fatal. The attracted candidate can reduce the ASSIM violations by one. It voices, violating RESIST 2, but decreasing the IV distance between the assimilation target and trigger. It therefore gets only one ASSIM violation, and so is the winner.

Under one definition of ASSIM the Hungarian-type unattracted output is selected. Under the other, the Krakow Polish-type attracted output is selected. With a single definition of a single constraint the contrast between the two languages can not be accounted for. I propose therefore that there is not a single ASSIM constraint, but rather that there are two related constraints for each assimilation process. These are given in (65). The definition of ASSIM in (61) is here accorded to the constraint IDENTICAL .

(65) Assimilation Constraints

IDENTICAL: The output {scale} values of adjacent segments must be *identical* .

ADJACENT: The output {scale} values of adjacent segments must be *adjacent* on the scale.[27]

In relating (the features of) two output segments these assimilation constraints invoke a correspondence-type relation between segments. This relation, and the assimilation constraints in (65), serve to link the two segments without any particular need for a geometric representation of the link, such as feature spreading and double linking. For other uses of a correspondence relation between output segments (but between corresponding segments in two morphologically related forms) see Benua (1995) and McCarthy (1995).

[27] A technical question of formulation is whether ADJACENT is satisfied or violated by the target and trigger being identical, i.e. closer than adjacent. If satisfied, the constraint should read 'no farther than adjacent' rather than 'adjacent'. However, given the universal ranking of IDENTICAL over ADJACENT in (64) it does not actually matter whether satisfying IDENTICAL implies violating or satisfying ADJACENT . For the present purposes I will not assign an ADJACENT violation to segments that satisfy IDENTICAL .

IDENTICAL is evaluated simply on whether full assimilation occurs or not, while ADJACENT only calls for attraction. Full assimilation is more favored than partial assimilation, so the ranking in (66) is universal.

(66) Universal ranking of assimilation constraints
IDENTICAL >> ADJACENT

Although the relative ranking of IDENTICAL and ADJACENT is fixed, constraints may intervene between them. It is just such an intervention that prevents attraction in languages such as Hungarian. In Hungarian RESIST 2 outranks ADJACENT but not IDENTICAL. Thus IDENTICAL can force RESIST 2 violations but ADJACENT can not. This is illustrated in the tableaux in (67). In (67a) the voiceless obstruent voices before a voiced obstruent under the force of IDENTICAL, which outranks RESIST 2. In (67b), where the voiceless obstruent is before a sonorant, IDENTICAL must be violated, because RESIST 3 outranks it. ADJACENT ranks below RESIST 2, so it can have no effect.

(67) IDENTICAL and ADJACENT in non-attracting cases

a) IDENTICAL forces assimilation of voiceless obstruent to voiced

/...p . d.../	RESIST 3	IDENTICAL	RESIST 2	ADJACENT
p . d		*!		
√ b . d			*	

b) ADJACENT fails to force attraction toward sonorant

/...p . n.../	RESIST 3	IDENTICAL	RESIST 2	ADJACENT
√ p . n		*		*
b . n		*	*!	
m . n	*!			

In (67a) the action of IDENTICAL is just like that of a general ASSIM. IDENTICAL outranks RESIST 2, so the voiceless obstruent can voice to assimilate to the following voiced obstruent. In (67b) IDENTICAL fails to cause assimilation to the sonorant, since RESIST 3 outranks IDENTICAL. ADJACENT also fails to have an effect, since it is ranked below RESIST 2. Thus the faithful, unattracted, unassimilated candidate wins.

The ranking of ADJACENT over RESIST 2 yields a pattern of attraction, as in Krakow Polish or certain dialects of Ukrainian. This is illustrated in (68). In (68a) the results are the same as in (67a): a voiceless obstruent voices before a voiced obstruent because IDENTICAL outranks RESIST 2. In (68b), however, the results are different. Here ADJACENT outranks RESIST 2. This means that when IDENTICAL fails to have an effect, ADJACENT is still active, forcing violation of RESIST 2. So a voiceless obstruent will voice so as to become adjacent on the scale to a sonorant.

(68) Attraction Rankings of IDENTICAL and ADJACENT

a) IDENTICAL forces assimilation of voiceless obstruent to voiced

/…k . b…/	RESIST 3	IDENTICAL	ADJACENT	RESIST 2
k . b		*!		
√ g . b				*

b) ADJACENT causes attraction toward sonorants

/…k . n…/	RESIST 3	IDENTICAL	ADJACENT	RESIST 2
k . n		*	*!	
√ g . n		*		*
ŋ . n	*!			

As in (67), the constraint ranking in (68) assures that IDENTICAL can only be satisfied if full assimilation does not require violation of RESIST 3. So the assimilation of voiceless obstruent to voiced obstruent in (68a) proceeds, since it requires only the violation of RESIST 2. In (68b), as in (67b), the ranking of RESIST 3 forbids assimilation to the sonorant. Unlike in (67), however, ADJACENT is ranked above RESIST 2. ADJACENT can be therefore be satisfied, and the voiceless obstruent voices to become IV-adjacent to the sonorant.

In both (67) and (68), assimilation of voiceless obstruents to voiced obstruents occurs, due to the ranking of IDENTICAL over RESIST 2. It is the ranking of the constraint ADJACENT (which can be ranked anywhere below IDENTICAL) that determines whether attraction occurs. If ADJACENT ranks above RESIST 2, then attraction will occur. If ADJACENT ranks below RESIST 2, then attraction will not occur.

The ADJACENT constraint makes crucial use of the ternarity and ordering of the scale. The attracted candidate in (68) wins because the scale value of the output coda is right next to (adjacent to) the scale value of the onset. The ternary IV scale thus successfully models the fact that voicing before sonorants is assimilatory, even though sonorants and obstruents have different types of voicing. They have different values on the IV scale, but moving from 1 to 2 (voiceless to voiced) on the scale is nonetheless moving close to 3 (sonorant).

2.7 Conclusions

This chapter has presented faithfulness constraints which are ranked according to the prominence of the scale levels to which they refer, so that STAY 3 and RESIST 3 dominate STAY 2 and RESIST 2, which dominate STAY 1 and RESIST 1. Faithfulness regulates the loss (STAY) and addition (RESIST) of scale values.

Constraints on assimilation may be ranked anywhere with respect to the faithfulness hierarchy, but due to the inherent ranking of the faithfulness constraints, assimilations involving sonorants (IV3) are rare. Since the ASSIM constraints may be ranked anywhere along the faithfulness hierarchy, a full typology of assimilations on the IV scale is expected. This typology was presented, based on the rankings of the ASSIM constraint with respect to the IV faithfulness constraints. Some rankings produce no assimilation (as in Punjabi), while other rankings produce assimilations that only involve obstruents and may therefore appear binary (as in Hungarian, Mekkan Arabic, Ukrainian, and Sudanese Arabic). Other rankings involve all three points of the scale (as in Catalan and Kaingang).

A single definition of an assimilation constraint does not explain why in some languages getting closer to an assimilation trigger is better than no change at all. The force behind assimilation is therefore broken into two constraints, one demanding strict identity between adjacent segments (IDENTICAL), and one demanding only adjacency (ADJACENT). Attraction is shown to be a scalar phenomenon, in which getting close (adjacent) on the scale is considered to be an assimilatory move.

The following chapter looks at chain shifting assimilations and consonant mutations, exploring further ways in which constraints refer to scale adjacency.

CHAPTER 3

CHAIN SHIFTING IV ASSIMILATIONS AND CONSONANT MUTATIONS

> The Britons, however, who of course still used the old pronunciation, understanding him to have called them 'Weeny, Weedy, and Weaky', lost heart and gave up the struggle, thinking that he had already divided them All into Three Parts.
>
> W.C. Sellar and R.J Yeatman, *1066 andAll That*

3.1 Introduction

In the previous chapter faithfulness constraints were proposed which are evaluated with respect to what scale value a segment possesses in the input and the correspondent output. An input value X which becomes Y in the output violates STAY X and RESIST Y. Using these constraints I considered assimilation and attraction, demonstrating how an appeal to a ternary scale allows an account of the attracting force of sonorants on obstruents in some languages and of the absence of such an effect in others. Chapter 2 accounted for simple assimilation and the more complex case of attraction, where $1 \rightarrow 2 / \_ \begin{Bmatrix}2\\3\end{Bmatrix}$.

These are not the only forms of assimilation, however. Consider the following chain shifting assimilation. In the vernacular dialects of much of central and southern Italy a voiceless obstruent is voiced after a nasal or lateral, while a voiced obstruent becomes a nasal after a nasal. The assimilation is shown is (1) (Chapallaz 1979).[1]

(1) Post-sonorant Assimilation in Southern Italian

a. Voiceless obstruent voices

Southern Italian	Other Italian	Spelling	Gloss
am**b**jo	am**p**jo	ampio	wide, roomy
man**d**ʒa	man**t**ʃa	mancia	tip

[1] Chapallaz does not specifically mention what happens to voiced obstruents after laterals. Presumably these retain their values. This may be due in part to the fact that laterals, unlike nasals, are not required to be homorganic with a following consonant. As seen in the case of Catalan in 2.4.1, homorganicity can play a part in sonorant assimilations.

mil**dz**a	mil**ts**a	milza	spleen
al**dz**a:re	al**ts**a:re	alzare	to lift

b. Voiced obstruents become nasals

gam**m**a	gam**b**a	gamba	leg
iɱɱe:tʃe	iɱ**v**e:tʃe	invece	instead
mon**n**o	mon**d**o	mondo	world
luŋŋo	lun**g**o	lungo	length

In (1a) a voiceless obstruent becomes voiced (IV1 → IV2), while in (1b) a voiced obstruent becomes a nasal sonorant (IV2 → IV3). Such chain-shifting processes have been intractable in standard theories of phonology (as pointed out by Foley 1977). Rule-based systems which have used binary features have not been able to capture the chain shifts as a single process, since the two halves of the chain shift involve different binary features (here [voice] and [sonorant]). Constraint-based models which use binary features encounter a similar difficulty: when assimilation is called for, the voiceless obstruent is for some reason prohibited from taking on [sonorant], but the voiced obstruent is permitted to. The change allowed in the output varies with the starting point, which is difficult to capture in OT.[2]

I claim that using ternary scales rather than binary features allows a proper analysis of chain-shifting movements. This chapter presents an analysis of these processes as they occur in assimilatory cases such as southern Italian and in nasalizing consonant mutations. I propose that in addition to the faithfulness constraints of Chapter 2, there is another set of faithfulness constraints which distinguish short-distance movement on the scale from long-distance

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[2] For other approaches to chain shift within Optimality Theory see McCarthy (1993a), Reiss (1995), and Kirchner (1995). Kirchner makes use of phonetic scales (like the present work), but retains standard binary features in the phonology (unlike this dissertation). Both Reiss and Kirchner propose that the faithfulness constraints mediating chain shift are ones which demand faithfulness to either of a set of two features. The constraint is satisfied if one of the two features is faithfully preserved, even if the other isn't, a solution which is unnecessary in the ternary scales framework.

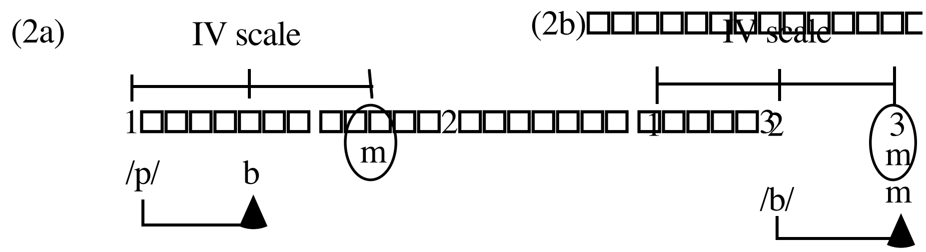
movements. I call these relative faithfulness constraints. This chapter is devoted to the effects of the relative faithfulness constraints, which include chain-shifting assimilation (Section 3.2), consonant mutations (Section 3.3) and the loss of structure preservation in coalescence (Section 3.4).

Section 3.2 motivates and describes the relative faithfulness constraints and applies them to the case of chain-shifting assimilation. Chain shifting assimilation is controlled by the relative faithfulness constraints, by which short-distance movement on a scale is preferred to long-distance movement, In Section 3.3 a number of nasalizing consonant mutations are presented. In these mutation contexts the relative faithfulness constraints are visible, mediating how far away the output's scale value can be from the input's scale value. Chain shift, long-distance movement, and no movement at all are different possible outcomes of mutation, depending on what constraints interact with the relative faithfulness constraints. Section 3.4 looks at coalescence (in mutation and elsewhere) and shows how the relative faithfulness constraints favor a coalescence which produces an output not too far from either of the two original input segments. The need for an output not to get too far away from either of two inputs sometimes leads to the creation of otherwise prohibited segments, a result not derivable in binary-feature theories.

3.2 Chain-shifting Assimilation

To establish the need for another set of faithfulness constraints, consider the southern Italian case above in (1). In southern Italian, the obstruents move one step on the IV scale. In (1a) an *mp* sequence becomes *mb*, as in as in *am**b**jo*, while in (1b) an *mb* sequence becomes *mm*, as in *gamma*. Voiceless obstruents (IV1) become voiced (IV2) and voiced obstruents (IV2) become sonorant (IV3). Presumably this is the result of assimilation constraints operating on postnasal and postlateral consonants.[3] The assimilation takes place of the IV scale, as illustrated in (2). The triggering segment and its IV value are circled.

(2) Southern Italian IV Assimilation



Part of the motivation for proposing ternary scales comes from just such processes as the chain shifting assimilation in southern Italian. The ternary scales capture representationally the idea that voiceless obstruents are to voiced obstruents as voiced obstruents are to sonorants. The movements from voiceless obstruent to voiced obstruent and from voiced obstruent to sonorant are both one step up the IV scale. Hence the order IV1 (voiceless obstruent), IV2 (voiced obstruent), IV3 (sonorant).

The ternary scale represents simply the ordered relations between the three voicing classes. What is essential about a scale as opposed to a multivalued feature is that the values on a scale are ordered with respect to one another. The order of a scale can be derived from knowing which values are adjacent to which other values. On a number line, for instance, if X is adjacent to both 3 and 5, I know that X is 4. A scale (of any size) can be constructed by knowing which values are adjacent to which others. A phonological scale therefore represents not only what values are related by being on a scale together, but also which

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[3] Alternatively, the postnasal voicing may be attributed to the *nasal+voiceless C constraint proposed by Pater (1995). Using this constraint, however, does not account for the assimilation of Southern Italian voiced obstruents to nasals or the voicing after laterals. The direction of assimilation (onset to coda) here is unusual, however, given that generally codas assimilate to onsets. It is tempting to speculate that there is some property of nasals (and laterals) which produces assimilation in onsets, given cases like the Italian above and the examples of nasalizing consonant mutations later in this chapter, where a nasal prefix causes changes in a stem-initial consonant.

values of that scale are adjacent to which others. Given that this is the case, it is only to be expected that the phonology would contain constraints which refer to the adjacency relation between scale values. This is done with constraints on relative faithfulness which, beyond checking for simple identity between input and output scale values, check whether the output's scale value is adjacent to that of the input. These constraints can then be used to analyze cases like the southern Italian, where the consonants move to adjacent IV values.

The constraints on relative faithfulness are shown in (3). They are called relative, because they evaluate the relation between input and output values, as opposed to the specific faithfulness constraints of Chapter 2, which refer specifically to the loss or addition of particular scale values. There will of course be a set of these constraints for each scale.

(3) Relative Faithfulness constraints

IDENT [X scale]: Given an input segment α and its correspondent output segment β, then α and β have identical values on the scale X.[4]
(In other words, the output may not have moved on the scale from the input.)

IDENT-ADJ [X scale]: Given an input segment α and its correspondent output segment β, then α and β must have related values on scale x, where the defined relations are *identity* and *adjacency*. (In other words, the output may not have moved *more than one step* on the scale.).

The basic force of faithfulness is that inputs and outputs must be identical. Any deviation from identity causes violations. I claim, however, that there are two

[4] IDENT [X scale] is basically McCarthy & Prince's (1995) IDENT[Feature], except that here IDENT considers a whole scale rather than a binary feature. Any change in the scale value violates IDENT [X scale]. This is similar to the way any change of value of a particular feature violates McCarthy & Prince's IDENT [Feature], although other work (e.g. Pater 1995) splits up IDENT into components according to whether the feature is added or lost (as in the STAY and RESIST constraints introduced in Chapter 2). The STAY and RESIST constraints are on each individual scale value, but IDENT [X scale] is a constraint on the whole scale.

different types of deviation from identity. One is the deviation of having an output value that is adjacent to—or bordering on—the input value. Values that are adjacent, while not participating in the relation of identity, still participate in the relation of adjacency, which is used to define the scale. The other deviation from identity is the worse deviation of having an output value that does not border on (is not even adjacent to) the input value. Such an output value has no relationship with its input. These two types of faithlessness are militated against by the constraints IDENT [IV] and IDENT-ADJ [IV]. IDENT [IV], is violated when the input and output values are neighbors on the scale, such as 1 and 2, or 2 and 3. IDENT [IV] is not violated when the input and output scale values are identical. IDENT-ADJ [IV] is violated when the input and output values are separated on the scale, such as 1 and 3. It is not violated by identical values or by adjacent values. Whenever IDENT-ADJ [IV] is violated IDENT [IV] is violated too, but I will not generally indicate this in the tableaux because the lower violation of IDENT [IV] will never be decisive when IDENT-ADJ [IV] is also violated.

If the output is adjacent to the input, the faithfulness violation is not as bad as when the output is not even adjacent and has no relation to the input. This leads to the following universal ranking.

(4) Universal Ranking of Relative Faithfulness Constraints[5]

IDENT-ADJ [X] >> IDENT [X]

By the ranking in (4) long movements on a scale are universally worse than short movements. The following table summarizes the action of IDENT [IV] and IDENT-ADJ [IV] on the IV scale.

[5] It would be reasonable to suppose that since IDENT [IV] is violated whenever IDENT-ADJ [IV] is, that the ranking between them would not be important. This is incorrect. As inspection of the tableau in (18) below shows, the constraints are not freely rerankable.

(5) Relative Faithfulness Constraint Violations

Scalar Movement	IDENT-ADJ [IV]	IDENT [IV]
1 → 2 p → b		*
1 → 3 p → m	*	(*)
1 → 2-3 p → ^{m}b		*
2 → 3 b → m		*
2 → 1 b → p		*
2 → 2-3 b → ^{m}b		
3 → 1 m → p	*	(*)
3 → 2 m → b		*
3 → 2-3 m → ^{m}b		

As table (5) shows, a change to a bordering scale value (1 → 2, 2 → 3, 2 → 1, 3 → 2) violates the lower ranked IDENT [IV], while a bigger change (1 → 3, 3 → 1) violates the higher ranked IDENT-ADJ [IV]. In the case of an output prenasalized stop, which has values IV2 and IV3, this violates IDENT [IV] for an input of IV1, and doesn't violate any relative faithfulness constraints for an input IV2 or IV3 (although it does still violate RESIST 2 or RESIST 3 in these cases). Since the prenasalized stop has values at both IV2 and IV3, it has a value adjacent to IV1. It has a value in common with either IV2 or IV3, so becoming a prenasalized stop does not violate IDENT [IV] for an IV2 or IV3 input. The case of prenasalized stops will be returned to in the discussion of eclipsis in 3.3 below.

In the case of southern Italian, the outputs violate IDENT [IV], but not IDENT-ADJ [IV]. IDENT-ADJ [IV] is not violated to satisfy the assimilation constraint, but IDENT [IV] is. This means that IDENT-ADJ [IV] dominates the assimilation constraint IDENTICAL, which dominates IDENT [IV]. Because movement toward but not all the way to the sonorant is undertaken in the interest of assimilation, we know that the assimilation constraint ADJACENT also dominates IDENT [IV]. The ranking is shown in the tableaux in (6), where the voicing of voiceless obstruents is shown in (a), and the nasalization of voiced obstruents is shown in (b).[6]

(6) Chain shift in southern Italian

a. Voicing of Voiceless Obstruents after Nasal

/am**p**jo/	IDENT-ADJ [IV]	IDENTICAL	ADJACENT	IDENT [IV]
am**p**jo		*	*!	
√ am**b**jo		*		*
am**m**jo	*!			

b. Voiced Obstruents become Nasal Sonorants

/gam**b**a/	IDENT-ADJ [IV]	IDENTICAL	ADJACENT	IDENT [IV]
gam**b**a		*!		
√ gam**m**a				*

In (6a) the first candidate is out because it violates both of the assimilation constraints. The third candidate is out even though it satisfies both assimilation constraints, because it has moved too far on the scale. The output value is not the same as, nor does it even border on, the input value. It violates IDENT-ADJ [IV]

[6] As in Chapter 2, it must be assumed that the faithfulness constraint regulating the addition of a nasal value is low enough ranked to be violated. I assume, with others, that take nasality as the default specification of sonorant consonants (e.g. Rice & Avery (1989) and Rice (1993)), that [nasal] is easily added, i.e. RESIST [nasal] is low ranking. I will not include the constraint in the tableaux except where it plays an important role.

fatally. The winning candidate is thus the one that splits the difference between faithfulness and assimilation, as the picture in (2a) above shows. It has moved to a scale position which borders on both its own input value and the assimilation trigger's scale value. Therefore it violates the faithfulness constraint IDENT [IV], but not the worse IDENT-ADJ [IV]. It violates the full assimilation constraint IDENTICAL, but not the attracting constraint ADJACENT.

In (6b), the winning output does not have to take a big step and violate IDENT-ADJ [IV] in order to be fully assimilated and satisfy IDENTICAL. It can satisfy IDENTICAL at the cost of only a low-ranking IDENT [IV] violation. So the *b* moves one step on the scale and becomes *m*, as shown above in (2b). The faithful first candidate fatally violates IDENTICAL. In both (6a) and (b), then, the successful candidates take only one step on the scale, violating IDENT [IV] but not the worse IDENT-ADJ [IV]. Because IDENT-ADJ [IV] outranks IDENTICAL, full assimilation will not happen if the input scale value is non-adjacent to the assimilation trigger's value. So *mp* (values 3 and 1) can not undergo full assimilation, but *mb* (values 3 and 2) can.

In addition to the relative faithfulness constraints in the tableaux in (6), the chain shifting assimilation also violates the specific faithfulness constraints RESIST 3, RESIST 2, STAY 2 and RESIST 1. Why is it that these faithfulness constraints do not control the shape of the assimilation, as they do in Chapter 2? The simple answer is that in chain shifting assimilations the active constraints are not those which refer to any specific value, but rather must be the relative faithfulness constraints, which refer to the distance between input and output. The pattern of the southern Italian assimilation could not be the result of constraints prohibiting movement into or away from any particular scale value (in other words, the specific faithfulness constraints). Voicelessness (IV1) and obstruent voicing (IV2) can both be lost, so the difference in the treatment of voiceless and voiced obstruents can not rest in the rankings of STAY 1 and STAY 2 with respect to ASSIM (or its IDENTICAL and ADJACENT subparts). Furthermore, voiced obstruents (IV2) and sonorants (IV3) can both be derived, so the difference in outputs can not stem from different rankings of RESIST 3 and RESIST 2 with respect to ASSIM. The argument is made more fully in the succeeding paragraphs.

Suppose that the faithfulness constraints of Chapter 2 were the only ones at work to counteract the assimilation in (2). Three sets of constraints would be at work: the RESIST constraints, the STAY constraints, and the assimilation constraints IDENTICAL and ADJACENT. The chart below compares the violations of output candidates for inputs /mp/ and /mb/. The only rankings given are those independently established, namely that RESIST 3 and STAY 3 dominate RESIST 2 and STAY 2, etc. and that IDENTICAL dominates ADJACENT.

(7) Constraint violations for /mp/ → *mb* and /mb/ → *mm*

a.	RESIST 3	STAY 3	RESIST 2	STAY 2	RESIST 1	STAY 1	IDENT-ICAL	ADJA-CENT
/mp/								
mp							*	*
√ mb			*			*	*	
mm	*					*		

b.	RESIST 3	STAY 3	RESIST 2	STAY 2	RESIST 1	STAY 1	IDENT-ICAL	ADJA-CENT
/mb/								
mb							*	
√ mm	*			*				

In order to establish a proper ranking in the chart in (7), the highest violation by the winning candidate in each case must be lower than the highest violation of the loser(s). In (7b) the fully assimilated *mm* is the winner. Its RESIST 3 violation must therefore be lower ranked than the loser's IDENTICAL violation.

The conclusion is that IDENTICAL dominates RESIST 3. Turning to (7a), however, we find that this ranking does not go through. If IDENTICAL outranks RESIST 3, then the IDENTICAL violation of the *mb* in the second candidate should doom it, since the *mm* obeys IDENTICAL and violates the (supposedly lower-ranked) RESIST 3. Based on the information in (7a) RESIST 3 should outrank IDENTICAL, since the candidate that violates RESIST 3 loses to a candidate that violates IDENTICAL.

The (a) and (b) parts of the chart in (7) can not be reconciled in their present state. The violations committed by the output of the /mb/ input in (b) suggest that RESIST 3 can be violated in order to assimilate to a nasal, while the violations committed by the output of the /mp/ input in (a) suggest that RESIST 3 can not be violated in the assimilation. Something must be regulating the process, then, other than the STAY and RESIST-type faithfulness constraints. The specific faithfulness constraints are therefore required.

A second question that could be asked is whether, given the necessity of the relative faithfulness constraints, the specific faithfulness constraints of Chapter 2 are still required. The answer is again yes. The relative faithfulness constraints do not distinguish between the movement of IV1 to IV2 and the movement from IV2 to IV3. Without the specific faithfulness constraints voicing assimilation and attraction should never be found without the assimilation of voiced obstruents to sonorants. Since such patterns are found in abundance (some cases of which are documented in Chapter 2), the specific faithfulness constraints are still required.

The specific faithfulness constraints do not control the shape of a chain shift, so they must be dominated in these cases. These constraints do, however, have the power to prohibit a chain shift if they are more highly ranked. If RESIST 3 outranks IDENTICAL, then 2 → 3 is prohibited, regardless of the rest of the ranking. The ranking of IDENT-ADJ [IV] is then irrelevant, since 1 → 3 is out anyway. Since the effects of the specific faithfulness constraints are well documented in Chapter 2, this chapter considers cases where they are lower ranked. The ranking of the relative faithfulness constraints can then be observed.

The southern Italian chain shifting assimilation in (1) is due to a particular ranking of the relative faithfulness constraints with respect to the assimilation constraints. Given the fixed order of the assimilation constraints (IDENTICAL >> ADJACENT) and the fixed order of the relative faithfulness constraints, there are six possible rankings of the two sets of constraints. The rankings are shown in (8), with the relative faithfulness constraints shown in bold.

(8) Possible rankings of Assimilation and Relative Faithfulness

a) IDENTICAL >> **IDENT-ADJ [X]** >> ADJACENT >> **IDENT [X]**
b) IDENTICAL >> **IDENT-ADJ [X]** >> **IDENT [X]** >> ADJACENT
c) IDENTICAL >> ADJACENT >> **IDENT-ADJ [X]** >> **IDENT [X]**
d) **IDENT-ADJ [X]** >> **IDENT [X]** >> IDENTICAL >> ADJACENT
e) **IDENT-ADJ [X]** >> IDENTICAL >> ADJACENT >> **IDENT [X]**
f) **IDENT-ADJ [X]** >> IDENTICAL >> **IDENT [X]** >> ADJACENT

If IDENTICAL is ranked above both the relative faithfulness constraints as in (a), (b) and (c), full assimilation is possible, subject to the rankings of the STAY and RESIST specific faithfulness constraints of Chapter 2. Depending on the ranking of the STAY and RESIST constraints the assimilation may take any of the forms (including no assimilation) found in Chapter 2. If assimilation to value 3 is ruled out by a high ranking RESIST 3, attraction may occur in (8a) and (8c), where ADJACENT outranks IDENT [IV]. By this ranking it is better for an assimilation target segment to become adjacent to the assimilation trigger's value than to avoid taking one step away from its underlying value. Since half the rankings are dominated by IDENTICAL, the specific faithfulness constraints control the shape of assimilation much of the time, and assimilation proceeds as in Chapter 2.

If both assimilation constraints are ranked below both the relative faithfulness constraints as in (d), no assimilation is possible, regardless of the rankings of the specific faithfulness constraints.

The rankings of interest here are (e) and (f), where IDENTICAL ranks between IDENT-ADJ [IV] and IDENT [IV]. In these cases, stepwise assimilation occurs if the specific faithfulness constraints are dominated. The ranking in (e) is the ranking responsible for the southern Italian chain shift, as shown in tableau (6) above. Since the chain shift pattern results from only one of the rankings of (8) and then only if the specific faithfulness constrains are dominated, such assimilation is understandably rare.

For completeness, I consider the ranking in (8f): IDENT-ADJ [IV] >> IDENTICAL >> IDENT [IV] >> ADJACENT. As in southern Italian, the ranking of IDENT-ADJ [IV] over IDENTICAL has the result that a segment can not fully assimilate to the non-adjacent value of an assimilation trigger. Unlike in southern Italian, however, IDENT [IV] is ranked above ADJACENT. This means that an adjacent movement may not be undertaken for attraction purposes, i.e. just to satisfy ADJACENT. An adjacent movement may only be undertaken to satisfy IDENTICAL. The assimilation would have the following pattern.

(9) Assimilation pattern predicted by ranking (8f)

	t → d / __ b (IV1 → IV2 / __ IV2)
BUT	t stays t / __ m (IV1 = IV1 / __ IV3)
	d → n / __ m (IV2 → IV3 / __ IV3)

This pattern is crucially different from the chain shift in southern Italian. Here voiceless obstruents voice only when assimilating to other obstruents, while the voiced obstruents are the only ones to assimilate to sonorants. Assimilation occurs only when it is full assimilation, not attraction (thus satisfying IDENTICAL) and only when it is performed by taking a small step on the scale rather than a big one (thus violating IDENT [IV] but not IDENT-ADJ [IV]). At this point I have not yet found a language exhibiting the pattern in (9).[7]

In summary the relative faithfulness constraints successfully account for chain-shifting assimilations. The ternary scales provide a framework in which a value can be related to another in two different ways. Just as in a binary system, an input value and an output value may or may not participate in the identity relations. In a scalar system, in input value and an output value may or may not participate in the adjacency relation. A value which is not identical to another can still be adjacent to it, as in 1 and 2, or 2 and 3. Alternatively, it may be farther removed and fail to participate in any relation with the other value, as in 1 and 3. This is the essence of a scale, and therefore such relations can not be expressed in binary features. Once the move to ternary scales has been made it is only sensible to have constraints which refer to both types of relationship. The two assimilation constraints (IDENTICAL and ADJACENT) and the two relative faithfulness constraints (IDENT-ADJ [IV] and IDENT [IV]) do just that.

3.3 Eclipsis Mutations

The previous section looked at a phonological assimilation that results in a chain-shift pattern. Chain shift is more common in the morphologically-infused domain of consonant mutations.[8] Consonant mutation occurs when a stem initial (or stem final, but all the cases I consider here are stem-initial) consonant changes according to its morphological environment. The present chapter looks at

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[7] But see 5.4.2 in which it is suggested that Pasiego Spanish may have the ranking in (9), although the evidence is not clear.

[8] The increased occurrence of chain shift in consonant mutation may be due to the fact that (as explained below) it is governed by the constraint MORPH REAL. Chain shift will generally result when MORPH REAL dominates IDENT [IV], even when it also dominates IDENT-ADJ [IV]. Of three possible rankings (below IDENT [IV], between IDENT [IV] and IDENT-ADJ [IV], and above IDENT-ADJ [IV]), chain shift will occur in two of them. Compare the case of assimilation, where chain shift can occur in only one of six possible rankings of the assimilation and relative faithfulness constraints.

consonant mutation that involves voicing and nasalization, and are analyzed as taking place on the IV scale. Another form of consonant mutation, lenition, will be discussed briefly in Chapter 5. Lenition involves loss of stricture, and is analyzed as taking place on the Consonantal Stricture (CS) scale.

An example of a nasalizing consonant mutation occurs in Irish (where it is called 'eclipsis'). Voiceless obstruents voice and voiced obstruents become nasal sonorants in nouns after second and third person plural possessives, after the cardinal numbers 7 through 10, and sometimes in prepositional objects (Ní Chiosáin 1991. See 3.3.1 for details.). Historically, the trigger for the mutation was a preceding nasal, but synchronically the trigger is morphosyntactic.

I propose that the eclipsis morpheme is an underspecified segment that contains only the value IV 3 and (sometimes, at least) the feature [nasal].[9] The use of an underspecified segment is similar to analyses where the mutation morpheme consists of solely of autosegments, e.g. Massam 1983, Lieber 1987, Kelly 1989. In order to be realized, the underspecified segment must undergo coalescence with the stem-initial segment. The form of the resultant coalesced segment is determined by the faithfulness constraints, as will be shown in more detail below and in subsequent sections.

In the following sections I will be looking at nasalizing mutations in the Celtic languages Irish, Welsh, and Scots Gaelic, in the Mande language Manya, and in the West Atlantic language Fula. The Celtic language group provides examples of similar mutations within a genetic language family, while Mande and Fula round out the typological survey of eclipsis. The basic form of the

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[9] The use of a segment that is necessarily underspecified may at first appear to run counter to the principles of OT, by which inputs are not constrained, and so can not be constrained to be underspecified. It is important to remember that while OT does not allow *constraints* on inputs, it certainly does allow *identification* of inputs, i.e. the conclusion that the underlying form of a particular morpheme has a particular shape, based on its behavior in the language. Identification of the morpheme is all that I am claiming to do here.

mutation will be the same in each case, with constraint ranking accounting for the differences between languages. The mutations are known as eclipsis, nasalization or prenasalization, depending on the language. In what follows I will call all of these processes by the general name of eclipsis. Although all these mutations involve nasals at some level, many of the segments undergoing mutation do not become nasal, so that a term such as 'nasalization' can be misleading.

Eclipsis can have any of the results listed in (10). The languages discussed which exhibit a particular effect are given in brackets.

(10) Results of Eclipsis

voiceless obstruents become voiced
(IV1 —> IV2) (Irish)

voiceless obstruents become voiced & prenasalized
(IV1 —> IV2-3) (Manya, Gaelic)

voiceless obstruents stay voiceless
(IV1 —> IV1) (Fula)

voiceless obstruents become nasal sonorants
(IV1 —> IV3) (Welsh)

voiced obstruents become nasal sonorants
(IV2 —> IV3) (Irish, Manya)

voiced obstruents become prenasalized
(IV2 —> IV2-3) (Fula)

liquids and glides become nasals
(IV3 —> IV3) (Manya)
[nasal]

glides become nasalized
(IV3 —> IV3) (Manya)
[nasal]

In some cases eclipsis can also involve the epenthesis of nasal or nasalized segments (Irish, Gaelic). Each language has some segments which resist eclipsis.

The list in (10) demonstrates that there are many possible outcomes of eclipsis across languages. A close look at (10) will also show that there are often several outcomes of eclipsis within a language, since most of the languages in the sample are listed more than once.

All these types of eclipsis, both within and across languages, can be analyzed as coalescence of an underspecified eclipsis morpheme with the stem-initial segment. The eclipsis morpheme is an underspecified segment that contains only the scale value IV3, and (sometimes, at least) the feature [nasal].[10] The eclipsis morpheme coalesces with the stem-initial segment, so that these two input segments share a single output segment. The shape of the coalescence is determined by the relative faithfulness constraints. So when Irish /p/ (IV1) becomes *b* (IV2) through coalescence with the eclipsis morpheme (IV3), the relative faithfulness constraint IDENT [IV] is violated (twice—once for the /p/ and once for the eclipsis morpheme), but the higher-ranked IDENT-ADJ [IV] is not violated. When /b/ becomes *m* (IV3), IDENT [IV] is once more violated, but IDENT-ADJ [IV] is not.

The use of an underspecified morpheme is similar to the use of morphemically-sponsored autosegments in analyses of mutation such as Massam (1983), Lieber (1984, 1987) and Kelly (1989). Eclipsis, particularly in Irish, has been extensively analyzed within generative phonology (e.g. Ní Chiosáin 1991, Rice 1993, Grijzenhout 1995, in addition to those mentioned above). According to Ní Chiosáin, Irish eclipsis is a rule shifting obstruents along the sonority hierarchy. Other approaches analyze eclipsis as the addition (through rule or association of morphemically sponsored autosegmental material) of [voice] and/or [sonorant] (Massam) or just [sonorant] (or its SV node

[10] The feature [nasal] is necessary to the analysis of Manya, in 3.3.3 below. In the other cases, the feature may or may not be present in the M morpheme, since inputs are not constrained in OT.

equivalent) (Kelly, Rice, Grijzenhout). In the former theory (i.e. that of Massam), [voice] and [sonorant] are arbitrarily related, while in the latter theory, a single [sonorant] (or SV) specification yields a voiced obstruent, while two such specifications yield a nasal sonorant. The analysis I present here, like that of Ní Chiosáin, places eclipsis on a scale. The scale is the Inherent Voicing scale, however, not the sonority hierarchy. In the theories of Massam, Kelly, Rice and Grijzenhout, nasal sonorants are represented as having 'more' of something than voiced obstruents have. I make the relationship between sonorants and voiced obstruents explicit by placing them adjacent to each other on the Inherent voicing scale and assigning sonorants more prominence on the scale. A further point is that in the approach presented here the eclipsis patterns in other languages are also accounted for. In some languages, for example, laterals become nasal in eclipsis. This move of a liquid to a less sonorous (but equally [sonorant] or SV) nasal can not be captured in any of the above theories, since they rely on increasing sonority or addition of [sonorant] or SV. In the present theory the eclipsis of liquids (and glides) can be accounted for, as shown in 3.3.3 for the Manya language.

In the present model the eclipsis morpheme (henceforth abbreviated M) is realized on the surface through coalescence with the stem-initial consonant. In Correspondence Theory (McCarthy & Prince 1995), coalescence occurs when two input segments correspond to one output segment. This is illustrated in (11) for the eclipsis of *p* in Irish. The subscripts indicate that the output *b* is in correspondence with both the input p and the input M.[11]

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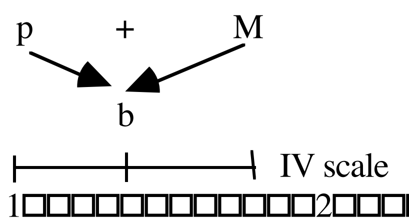
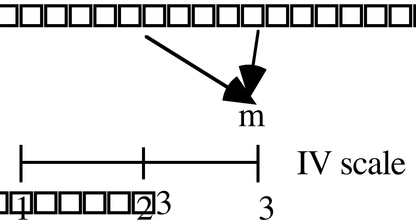
[11] Given the model of correspondence that I am using (segments stand in correspondence, features don't) it is crucial that M be a segment (though underspecified), not just a floating feature. I am not, however, ruling out the possibility of an analysis in which the IV3 value is not associated with a segment (as in Zoll 's (1996) treatment of subsegmental material), provided that the scale values then are given their own correspondence relations.

(11) M_1 + p_2 (input)
$b_{1,2}$ (output)

In its underlying form the M is underspecified and unsyllabifiable, since it contains only the value IV3 (and, in some cases at least, the feature [nasal]). M must coalesce with the stem segment so that its output correspondent can have place and stricture features and be syllabified.

The coalesced output *b* in (11) is not fully faithful to either M or /p/, the two input segments. On the IV scale the output (IV2) is adjacent to both M (IV3) and /p/ (IV1), as shown in the diagram in (12a). This 'averaging' of scale value is due to the fact that the mutation segment and the stem segment have conflicting faithfulness requirements. Faithfulness to the mutation segment M requires that the output be IV3, while faithfulness to the stem segment /p/ requires that the output be IV1. The result is that both the input /p/ and the M incur a violation of IDENT [IV] in taking on the 'averaged' value in *b*. In (12b) the coalescence of /b/ and M yields *m*, which is fully faithful to the M's IV3 value at the cost of a IDENT [IV] violation for /b/. In both cases IDENT [IV] is violated, but not IDENT-ADJ [IV].

(12a)


(12b)


The coalescence in (12) is not a cost-free procedure. Coalescence violates the segmental faithfulness constraint UNIFORMITY, which demands that segments which are distinct in the input remain separate in the output (McCarthy & Prince 1995. UNIFORMITY is introduced as NO-COAL in Gnanadesikan 1995b. See also Lamontagne & Rice 1995 and Pater 1995 for treatment of coalescence in OT.). In languages with consonant mutation, something must force the coalescence to occur. In other words, there must be a constraint that ranks above UNIFORMITY, that is satisfied by coalescence. The driving force behind the mutation is the need for the eclipsis morpheme to be given some surface phonological effect. Since M is required to surface, coalescence occurs as the best way to satisfy syllabification requirements.

To enforce the phonological realization of the underspecified morpheme, I use Samek-Locovici's (1992, 1993) Morpheme Realization:

(13) Morpheme Realization: 'Realize the morpheme in an overt and detectable manner'

In other words, the eclipsis morpheme must have a surface phonological effect. The affixed form of a word (with the eclipsis morpheme) should not look like the unaffixed form of a word (without the eclipsis morpheme)—zero morphemes are specifically prohibited by this constraint.

The principle of Morpheme Realization is similar to the MORPH-DIS (Morphemic Disjointness) of McCarthy & Prince (1995), which states that 'Distinct instances of morphemes have distinct contents, tokenwise' (p62). Mophemic Disjointness would be violated if the output of mutation (with two morphemes, each demanding separate contents) looked just like the unmutated form (with one morpheme). I use Morpheme Realization over Morphemic Disjointness, however, because in the consonant mutations considered here the mutated output segment often has a scale value between the stem segment's underlying value and the mutation morpheme's underlying value. To which morpheme does the 'averaged' scale value belong? To avoid this conundrum I use the more general Morpheme Realization: the 'averaged' scale value realizes the morpheme, since the output value is closer to the underlying mutation morpheme's value than the unmutated stem segment's value is.

On the basis of the mutations analyzed in this chapter, Morpheme Realization can be defined more specifically, to provide the answer to what, exactly, realization of a morpheme means. I offer the following more specific definition.

(14) Morpheme Realization (MORPH REAL):
A Morpheme must be realized by fulfilling one of the following conditions:
(a) the output affixed form contains at least one segment not in the unaffixed form, and that segment(s) is coindexed with a segment(s) in the affix's input
(b) the output affixed form contains a segment which is coindexed with the affix's input and that segment has a scale (or feature) value contained in the affix's input but not in the unaffixed form
(c) the output affixed form contains a segment which is coindexed with the affix's input and that segment has a scale value adjacent to that of the affix's input. That value does not occur in the unaffixed form.

A morpheme can thus be realized by (a) addition of segments, (b) lending its feature or scale value(s) to a coalesced output (where these values did not already occur by virtue of being in the stem segment) or (c) causing a scale value to become adjacent to its input scale value (where the value was not already adjacent by virtue of the values in the stem segment). The (a) case is normal segmental affixation, while the (b) and (c) cases are concerned with coalescing affixation as in mutation. As in other aspects of phonology (assimilation, faithfulness), a scalar model of morpheme realization refers to the adjacency relation on the scale.

Morpheme Realization and syllabification constraints drive coalescence of the underspecified eclipsis morpheme (henceforth abbreviated M) with the stem-initial segment. In any language with consonant mutation, Morpheme Realization must be ranked highly enough to cause violations of UNIFORMITY, so UNIFORMITY will not be mentioned further. Also assumed is the high ranking of

MAX, which ensures that the stem segment does not delete to give way to M (the deletion of M itself is prohibited both by MAX and by MORPH REAL).

Morpheme Realization ensures that the output of the mutation is not the same as the input stem-initial segment. In the present example, it rules out M + *p* = *p*. However it does not determine the actual shape of the mutated segment, since an output of either *m* or *b* (or even ^{m}b) would also satisfy it. Indeed, all of these outputs occur in the language sample discussed below, and outlined briefly in (10) above. In the straightforward chain-shift of Irish, M + *p* yields *b*, violating IDENT [IV] twice (Section 3.3.1). In Hebridean Gaelic and Manya M + voiceless stop yields a prenasalized stop, violating IDENT [IV] only once and fully realizing the M's IV3 (Section 3.3.2–3). In Welsh M + *p* yields *m*, which violates the high-ranked IDENT-ADJ [IV] (Section 3.3.4) In Fula, the M + *p* mutation fails, because MORPH REAL is dominated by IDENT [IV] (Section 3.3.5).

The particular shape of the mutated segment is determined by the ranking of the relative faithfulness constraints with respect to Morpheme Realization and certain markedness constraints. Different rankings of these constraints with respect to each other will yield the different patterns of eclipsis observed in different languages. I turn now to language-specific examples of eclipsis to demonstrate the different rankings.

3.3.1 Eclipsis in Irish: Basic Chain Shift

The initial consonants that can occur stem initially in non-mutated (radical) contexts in Irish are shown in (15) (Ní Chiosáin 1991[12]), where C' indicates a palatalized consonant.

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[12] All Irish data is from Ní Chiosáin (1991).

(15) Irish Consonants: Radical Initial

p p'	t t'	k k'	
b b'	d d'	g g'	
f f'	s s'		h
m m'	n n'		
	l l'		
	r r'		

When a noun is preceded by a second or third person plural possessive pronoun or the cardinal numbers 7 through 10, it undergoes eclipsis. In some dialects nouns also undergo eclipsis when they are prepositional objects. (In other dialects, they undergo lenition in this environment, although when prepositional objects beginning with coronals are preceded by coronal-final proclitics they do not undergo any mutation.) The eclipsis causes the changes in (16).

(16) Irish Eclipsis

Radical ⇒	Eclipsed	Radical ⇒	Eclipsed	No Change
p, p'	b, b'	b, b'	m, m'	m, m'
t, t'	d, d'	d, d'	n, n'	n, n'
k, k'	g, g'	g, g'	ŋ, ŋ'	h
f, f'	v, v'			s, s', l, l', r, r'

The general pattern of Irish eclipsis is that of a chain shift: stem-initial voiceless segments become voiced, and stem-initial voiced segments become nasal sonorants. Sonorants, *s*(') and *h* are immune. Examples of Irish eclipsis are given in (17).

(17) Irish Eclipsis Examples (Irish orthography in brackets)

Radical	Eclipsed
t'ax (teach) 'a house'	ə d'ax (a dteach) 'their house'
	s'axt d'ax (seacht dteach) 'seven houses'
kootə (cóta) 'a coat'	ə gootə (a gcóta) 'their coat'
g'atə (geata) 'a gate'	wur ŋ'atə (bhur ngeata) 'your (pl.) gate'
dorəs (doras) 'a door'	ə norəs (an ndoras) 'their door'
	s'axt norəs (seacht ndoras) 'seven doors'
boskə (bosca) 'a box'	ər ə moskə (ar an mboska) 'on the box'

3.3.1.1 Analysis of Basic Irish Pattern

Irish eclipsis has been extensively analyzed within generative phonology (e.g. Massam 1983, Kelly 1989, Ní Chiosáin 1991, Rice 1993, Grijzenhout 1995), as mentioned in the previous subsection. In the ternary scales theory presented here, the Irish eclipsis chain shift is the result of the interaction between Morpheme Realization and the relative faithfulness constraints. In order to satisfy Morpheme Realization (MORPH REAL), the stem segments move one step on the IV scale. Therefore MORPH REAL must dominate IDENT [IV]. The eclipsis of voiceless obstruents in Irish is shown in (18). For the sake of the example, *t* is used as the stem initial segment, but the results are analogous for *p*, *k* and *f* and their palatalized forms (for *s* see below). The violation of UNIFORMITY in the coalescing candidates is not shown. UNIFORMITY must rank below MORPH REAL in Irish and in all the other mutating languages discussed in this chapter, so I leave it aside.

(18) Eclipsis of voiceless obstruent in Irish

$M_1 + t_2$	MORPH REAL	IDENT-ADJ [IV]	IDENT [IV]
a. $t_{1,2}$	*!	*	
b. t_2	*!		
c. $n_{1,2}$		*!	*
d. √ $d_{1,2}$			**

The outputs in (a) and (b) of tableau (18) are the same except that in (a) the output *t* is the correspondent of both the input M and *t*, while in (b) the coalescence has not occurred, and the output *t* is the correspondent of only the input *t*. Both of these candidate outputs violate Morpheme Realization, since the M morpheme has no overt effect. The first candidate also violates IDENT-ADJ [IV], since the output *t*'s IV1 value is non-adjacent to M's underlying IV3 value. This is a case of invisible coalescence, so-called because the output *t* looks like a non-coalesced output of just one of its input segments (for use of invisible coalescence see Gnanadesikan 1995b). Invisible coalescence always violates MORPH REAL, but MORPH REAL can be violated without violating IDENT-ADJ [IV], as candidate (b) shows. Nevertheless (b) is out because MORPH REAL is highly ranked.

Candidate (c), which goes all the way to an IV3 nasal, violates the highly ranked IDENT-ADJ [IV] . The *t* (IV1) has become an *n* (IV3), which is a non-adjacent movement. The M (IV3), on the other hand, has not moved at all on the scale, violating no relative faithfulness constraints. The long movement of the stem *t* rules this candidate out, even though the M does not move at all.

The winner is candidate (d). In this case the coalesced output is *d*, which borders on both the input value of M and the input value of the *t*, incurring two violations of IDENT-ADJ. The contrast between candidates (c) and (d) illustrates the need for the two separate constraints IDENT [IV] and IDENT-ADJ [IV] instead of a single gradient faithfulness constraint that would assign one violation for each scalar step that the output diverges from the input.[13] In candidate (c) the total divergence is two steps: the output diverges from /t/ by two steps and from M by none, for a total of two. In candidate (d) the total divergence it also two steps: the output diverges from /t/ by one step and from M by one, for a total of two. Although the total divergence is the same in (c) and (d), the candidate in (d) diverges only slightly from each of its inputs, while the candidate in (c) diverges widely from one of them. Thus two short hops are not as bad as one long jump, and we need the separate constraints IDENT [IV] and IDENT-ADJ [IV] to distinguish them.

The tableau in (18) also serves to illustrate the importance of the ranking between IDENT [IV] and IDENT-ADJ [IV]. Since technically IDENT [IV] is assigned violations for *any* deviation from identity (non just adjacent ones), then it would seem as though IDENT [IV] and IDENT-ADJ [IV] would be freely rerankable. Non-adjacent movements would be worse than adjacent movements simply because they violated two faithfulness constraints instead of just one. This is the reason for the violation of IDENT [IV] in (18c). (Such violations of IDENT [IV] when IDENT-ADJ [IV] is also violated are generally left out.) Reranking IDENT [IV] and IDENT-ADJ [IV] doesn't work: (18c) would incorrectly come out the winner. The ranking of IDENT-ADJ [IV] over IDENT [IV] (by which one violation of IDENT-ADJ [IV] is worse than two violations of IDENT [IV]) is necessary.

Returning to the facts of the Irish case, underlying voiced obstruents become nasal sonorants, taking a short hop on the IV scale and violating

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[13] Having a change of two steps be governed by a separate constraint than two separate changes of one step is similar to Smolensky's (1995) Local Self Conjunction, whereby two violations of a single constraint within a certain domain violates a single, higher ranked constraint, as discussed further in 3.5.

IDENT [IV]. Tableau (19) shows the derivation of nasal sonorants from voiced obstruents. The example is *d*, but the analysis is equivalent for *b* and *g*.

(19) Eclipsis of voiced obstruent in Irish

$M_1 + d_2$	MORPH REAL	IDENT-ADJ [IV]	IDENT [IV]
a. $d_{1,2}$	*!		*
b. √ $n_{1,2}$			*

In candidate (a) the eclipsis morpheme is not realized, since the output looks just like the unaffixed input. Candidate (b) is therefore the winner. As in (18), the winning candidate realizes the morpheme at the low cost of violating IDENT [IV]. The tableau in (19) illustrates one function which the MORPH REAL constraint serves. Both candidates (a) and (b) have the same faithfulness violations: they violate IDENT [IV] once. It is the force of MORPH REAL which chooses (b) over (a).

As tableaux (18) and (19) demonstrate, eclipsis is a coalescence made in order to realize the eclipsis morpheme. The form of the coalescence is determined by the relative faithfulness constraints. By the ranking of the relative faithfulness constraints, short hops taken on the scale are preferred to long jumps, so the result is a chain shift.

3.3.1.2 Further Considerations

The above section describes the basic system of Irish eclipsis. As the chart in (16) shows, however, there are some segments in Irish that do not undergo eclipsis. Some do not undergo eclipsis because the expected eclipsed segments are not permissible in the language. Although eclipsis sometimes violates constraints on segment inventory (see section 3.4), it sometimes obeys them, depending on the ranking between the inventory constraint(s) and MORPH REAL. In the present case, *s* does not become *z*, and *h* does not become ɦ, because the constraints against *z* and ɦ are highly ranked in Irish. A minimal change on the IV scale would violate an inventory constraint which outranks MORPH REAL. This is shown in (20) for /s/, where '*z' stands for whatever inventory constraint disallows *z* in Irish.

(20) Failure of /s/ to undergo eclipsis

M + s	*z	MORPH REAL
√ s		*
z	*!	

Another possible way for *s* to satisfy Morpheme Realization would be to have *s* take a larger step on the IV scale and become *r* or even *n*. In becoming *r* or *n*, *s* would violate IDENT-ADJ [IV] and also RESIST [rhotic] or STAY CS2, as well as STAY [strident].[14] STAY [strident] and STAY CS2 are both violated in Irish lenition (discussed in 5.3.1), so this establishes IDENT-ADJ [IV] as ranked above MORPH REAL, a ranking left indeterminate in tableaux above. Tableau (21) illustrates this for *s*. Similar things can be said about *h*.

(21) Further failure of /s/ to undergo eclipsis

M + s	*z	IDENT-ADJ [IV]	MORPH REAL
√ s			*
z	*!		
r / n		*!	

The other consonants which resist eclipsis are the sonorants. In the case of the nasals there is nothing they can do to realize the eclipsis morpheme: they are already [nasal] and IV3. Morpheme Realization is doomed to violation in these

[14] In order to have a single system of featural faithfulness constraints I use STAY and RESIST for features which are not on ternary scales as well as for scale values. STAY and RESIST have meanings which translate simply, so that STAY[strident] is violated if an underlying [strident] is lost from a segment and RESIST [nasal] is violated if a non-underlying [nasal] is added to a segment. Binary features can also be seen as binary scales.

cases. In the case of the liquids, these consonants could theoretically become nasal. They do not do so, for one of three reasons. The first possible reason is that [nasal] is actually not a part of the eclipsis morpheme: it is only specified as IV3. That would mean that liquids, like nasals, can not do anything to realize the eclipsis morpheme. The fact that voiced obstruents undergoing eclipsis take on [nasal] and not, say, [lateral] could be simply because they are stops and/or because [nasal] is the default specification for sonorant consonants. In such a case liquids, like nasals, could not possibly satisfy MORPH REAL. Although this approach would work and may indeed be true, other languages, such as Manya, have eclipsis morphemes which must contain the specification [nasal]. To explore a more fully parallel treatment of the different eclipsing languages I will not assume this solution here.

The other possible reasons are that either STAY CS2 (forbidding liquids to lose continuance to become nasal stops) or STAY [lateral] and STAY [rhotic] must be ranked above Morpheme Realization. The option of ranking STAY [lateral] above MORPH REAL is shown in tableau (22).[15]

(22) Failure of /l/ to undergo eclipsis

M + l	STAY [lateral]	MORPH REAL
√ l	*!	
n		*

When a vowel-initial stem occurs after an eclipsis-triggering proclitic it takes on an epenthetic *n*, so that *asəl* (asal, 'donkey') is *nə nasel* (na n-asal) in the plural genitive definite. Ní Chiosáin (1991) argues that Irish stems which appear to be vowel-initial actually begin with an underspecified consonant.[16] Whether

[15] In the Irish lenition mutation, STAY CS2 can be violated, since *s* (CS2) becomes *h* (CS3), so I do not rank STAY CS2 above MORPH REAL.

[16] Part of the argument in favor of this position comes from palatalization and non-palatalization of a proclitic-final consonant before the vowel-initial word. The palatalization of the proclitic-

or not this is the correct analysis, it is true that in vowel initial words there is no overt onset segment for M to coalesce with. After proclitics which do not trigger mutation, the vowel-initial stems receive an epenthetic onset: a *t* after a consonant-final proclitic (all proclitic-final consonants are coronal) or *h* after a vowel-final proclitic. After proclitics which do trigger eclipsis, the eclipsis morpheme is free show up on the epenthetic segment, making it *n.* Because the epenthetic segment has no underlying IV value, relative faithfulness to the stem is irrelevant. The faithfulness constraints on the eclipsis morpheme are allowed free rein, and an IV3 nasal shows up. This is illustrated in tableau (23).

(23) Eclipsis in epenthetic cases

M + Ø	IDENT-ADJ [IV]	MORPH REAL	IDENT [IV]
a. t	*!	*	
b. d			*!
c. √ n			

In candidate (a), an output of *t* does not satisfy MORPH REAL. It does have an IV value, like M, but it is not the same or adjacent to M's IV3 value. More importantly, (a) violates IDENT-ADJ [IV], being far from having M's IV3 value. An output of *d* (candidate (b)), is closer to M, and violates only IDENT [IV]. Even the violation of IDENT [IV] is too much, since there is nothing forcing such a violation. Candidate (c), which has M's IV value, is therefore the winner. Because there is no other underlying IV value (and so no other faithfulness requirements), M's IV3 value is free to show up, and indeed must show up.

final consonant is not predictable based on the word-initial vowel. Rather it seems that there is a word-initial position where palatalization can be specified without being on an overt segment. The same residual palatalization can be observed when a word-initial consonant is deleted (as in lenition of *f*, see Chapter 5). If the consonant is truly deleted, then a floating palatalization feature must be possible without belonging to a segment. However, the status of floating features within Correspondence Theory is not clear at this time.

3.3.1.3 Irish Summary

As the preceding subsections show, Irish eclipsis is basically a chain shift of obstruents: IV1 to IV2, and IV2 to IV3. The chain shift occurs under pressure from the eclipsis morpheme, which contains IV3 and perhaps [nasal]. The core ranking responsible for the chain shift in given in (24a). Sonorants, *s*, and *h* are immune to eclipsis due to the impossibility of satisfying Morpheme Realization in the case of the nasals and due to higher ranked inventory and faithfulness constraints in the case of the liquids, *s* and *h*. The constraint ranking forbidding eclipsis of liquids is given in (24b), and that forbidding eclipsis of *s* and *h* is given in (24c).

(24) Summary of Ranking in Irish

a) MORPH REAL >> IDENT [IV]
b) STAY [lateral, rhotic] >> MORPH REAL
c) IDENT-ADJ [IV], *z, *ɦ >> MORPH REAL

When eclipsis is accompanied by epenthesis, the IV3 (and [nasal]) values of the eclipsis morpheme can show up without interference from the stem faithfulness constraints.

3.3.2 Eclipsis in Gaelic: Prenasalization

I turn now from Irish to the closely related Scots Gaelic language. Certain dialects of Scots Gaelic eclipse by prenasalization. Although some dialects of Gaelic have an eclipsis process essentially like that in Irish (Calder 1972 [1923]), most dialects of the Outer Hebrides and of Ross-shire use prenasalization (Borgstrøm 1940). Hebridean Gaelic has the following consonants in radical initial position where, as in Irish, palatalization is marked with an apostrophe. (Tense coronal sonorants are shown with capital letters.)

(25) Radical Initial Consonants of Hebridean Gaelic

p^h	t^h $t^{h'}$	k^h $k^{h'}$
p	t t'	k k'
m	n N N'	
f	s s'	h
	l L L' r R r'	

As comparison with (15) will show, the major difference here between Irish and Hebridean Gaelic is that Irish has a voicing contrast in stops, while in Hebridean Gaelic the contrast is one of aspiration. This difference is important, for it means that in Hebridean Gaelic the unmutated obstruents all have a single IV value, namely IV1. The Irish chain shift, in which each IV class moves up one (1 → 2, 2 → 3) therefore can not occur. Unlike the Irish chain shift, Gaelic eclipsis is not structure preserving, since it creates prenasalized stops, as shown in (26). The implications and analysis of non-structure-preserving coalescence are discussed in 3.4.

(26) Eclipsis in Hebridean Gaelic

Radical ⇒	Eclipsed	Radical ⇒	Eclipsed	No Change
p^h	${}^{m}b^{h}$ [17]	p	${}^{m}b$	f m
t^h $t^{h'}$	${}^{N}d^{h}$ ${}^{N}d^{h'}$	t t'	${}^{N}d$ ${}^{N}d'$	s s' N N'
k^h $k^{h'}$	${}^{ŋ}g^{h}$ ${}^{ŋ}g^{h'}$	k k'	${}^{ŋ}g$ ${}^{ŋ}g'$	h
				L L' R

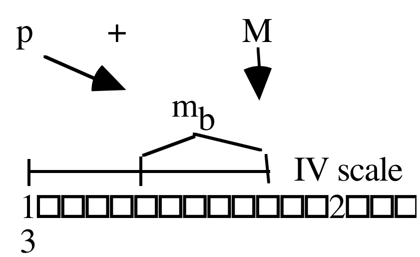
As in Irish, nasals, liquids, *s* and *h* do not become eclipsed. Besides these, Gaelic adds *f* to the list of eclipsis-resisting segments. In Gaelic, therefore, the

[17] Borgstrøm (1940) describes the stop portion of the aspirated prenasalized stops as having very little voicing. In the South Hebrides and Ross-shire, where the stop portion is comparatively longer, he transcribes it as slightly voiced, while in the Skye & Lewis dialects the stop portion is very short and he transcribes it as voiceless. Any voicing in the very short stop of Skye & Lewis may be overshadowed by the aspiration. On the other hand, this may be a true instance of the marked voiceless prenasalized stop (appearing due to high-ranking constraints against losing the aspiration or of creating aspirated IV2 segments). I concentrate here mainly on the South Hebridean/Ross-shire varieties and assume for the sake of simplicity that the difference in noticeable voicing (as well as in the comparative length of the stop) is simply phonetic.

markedness constraint militating against voiced fricatives in general outranks MORPH REAL, while in Irish it is only the constraint against the voiced strident *z* that outranks MORPH REAL. Otherwise, the resistance to eclipsis is just like that in Irish, shown in tableaux (21) and (22). In not creating *z*, *v* or ɦ, Gaelic respects inventory constraints, which it does not in creating prenasalized stops. Section 3.4 shows how the ranking of MORPH REAL can result in structure preservation in some cases and failure of structure preservation in others.

The difference between Irish and Gaelic to be treated here is the presence of prenasalization. In Irish voiceless obstruents become voiced, while in Hebridean Gaelic they become voiced and prenasalized. When the voiceless stops become voiced prenasalized stops, they are taking on a bordering IV value. As in the Irish case, where only adjacent moves are made, the voiceless stops are moving to a bordering value on the IV scale (IV2-3), but not to a non-adjacent one (IV3). This is shown in the picture in (27).

(27)



Gaelic eclipsis, like Irish eclipsis, proceeds with IDENT [IV] violations, but not with the worse IDENT-ADJ [IV] violations, as shown in tableau (28).

(28) Eclipsis of voiceless stop in Hebridean Gaelic

M + p	MORPH REAL	IDENT-ADJ [IV]	IDENT [IV]
a. p	*!		
b. m		*!	
c. b			**!
d. √ mb			*

In (a) a voiceless output fatally violates MORPH REAL. In (b), a nasal sonorant output violates IDENT-ADJ [IV]. It is too far away from the input /p/. In (c) there are two violations of IDENT [IV], since the voiced output *b* borders on both the IV1 value of the /p/ and the IV3 value of M. This candidate is not chosen: candidate (d), which contains a prenasalized stop (with values IV2 and IV3) is more faithful to the inputs. The prenasalized stop borders on the voiceless stop's IV1 value, and it coincides with the M's IV3 value. Therefore there is only one IDENT [IV] violation. The prenasalized stop is more faithful to its two input segments than a regular voiced stop is.

The tableau in (28) does not take into account the fact that prenasalized stops are marked segments and therefore violate a high-ranked markedness constraint, here designated *PRENASAL. In Hebridean Gaelic prenasalized stops do not appear in other contexts, so *PRENASAL must be high ranking. In the coalescence environment of eclipsis, however, *PRENASAL is violated. Candidate (d) in (28) violates *PRENASAL, as shown in (29).

(29) Violation of *PRENASAL in Gaelic

M + p	IDENT [IV]	*PRENASAL
b	**!	
√ ^{m}b	*	*

By tableau (29), the violation of *PRENASAL by the ^{m}b is irrelevant, because *b* violates IDENT [IV] twice to ^{m}b's once and so is eliminated from consideration. In other (non-coalescing) cases, however, the *PRENASAL constraint is decisive. In order for an input prenasal to satisfy *PRENASAL it must simply lose its IV2 or IV3 (and [nasal]) value. This would violate STAY 2 or STAY 3, but not the higher ranked IDENT [IV]. The difference in effects of inventory markedness constraints between coalescence and non-coalescence environments is taken up in section 3.4.

In Irish the situation is different. The regular voiced stop is chosen over the prenasalized stop. This means that in Irish the markedness constraint against prenasalized stops ranks yet more highly than in Hebridean Gaelic. The markedness constraint *PRENASAL must rank above IDENT [IV] in Irish. Thus in Irish it is more important to avoid prenasalized stops than it is to minimize the IDENT [IV] violations. The tableau in (30) demonstrates the avoidance of prenasalized stops in Irish.

(30) Prenasalized stops are not derived in Irish

M + p	*PRENASAL	IDENT [IV]
a. ^{m}b	*!	*
b. √ b		**

In tableau (30) the first candidate incurs only one IDENT [IV] violation, since it borders on the /p/'s IV1 value, and coincides with the M's IV3 value. This high level of faithfulness is irrelevant, however, since the prenasalized stop violates the higher ranked *PRENASAL. Candidate (a) is therefore out. Candidate (b) incurs two IDENT [IV] violations, but it is optimal because it is not prenasalized.

In Irish, therefore, it is crucial to avoid prenasalized stops, since *PRENASAL outranks IDENT [IV]. In Gaelic, prenasalized stops (though still highly dispreferred—see 3.4.2) are derived so as to minimize violations of IDENT [IV]. By the ranking of IDENT [IV] over *PRENASAL, Gaelic allows prenasalized stops as the output of eclipsis. By the opposite ranking Irish prohibits prenasalized stops. The difference in eclipsis outputs between Hebridean Gaelic voiceless stops and Irish voiceless stops is therefore due to different rankings of the markedness constraint *PRENASAL with respect to IDENT [IV].

In the dialects of the South Hebrides and of Ross-shire (on the mainland), the epenthetic eclipsis segment is *N* (the tense version of the coronal nasal—in unlenited initial position the coronal sonorants are tense).[18] The South Hebridean/Ross-shire case is like Irish, where the IV3 and [nasal] values of the eclipsis segment show up under epenthesis, since there is no stem segment there with conflicting faithfulness requirements. The input is free to be fully faithful to the M's IV3 value. This is shown in tableau (31), where the constraint TENSEINIT requires initial coronal sonorants to be tense.

(31) Eclipsis of epenthetic segment in South Hebridean Gaelic

M + Ø	MORPH REAL	IDENT-ADJ [IV]	IDENT [IV]	TENSEINIT
a. t	?	*!		
b. d			*!	
c. n				*!
d. √ N				

In (31) there is only one input segment, so the faithfulness constraints only make reference to the M segment, which contains IV3. Any deviation from IV3, as in candidates (a) and (b) incurs a gratuitous faithfulness violation of IDENT-ADJ [IV] or IDENT [IV]. Candidates (c) and (d) are faithful to M's specifications, but (d) wins because it meets the requirement of being tense.

A final distinctive point of the Hebridean dialects is that the aspiration on the radical consonant is preserved in eclipsis. The distinction between maintaining aspiration and neutralizing it is well demonstrated in the Gaelic of Applecross, in Ross-shire on the mainland, where prenasalization does not occur (voicing is the sole effect of eclipsis). Ternes (1973) reports that in Applecross there are two dialects, one of which maintains aspiration under eclipsis and one

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[18] In Skye and Lewis, the situation is somewhat different. According to Borgstrøm (1941), the epenthetic eclipsis segment is *Nd*. This is discussed more fully in 3.4.2.

of which does not. This is illustrated in (32), which lists only the segments undergoing eclipsis. Unaffected segments are as in (26).

(32) Applecross Gaelic eclipsis

a) Conservative dialect

Radical ⇒	Eclipsed	Radical ⇒	Eclipsed
p^h	b^h	p	b
t^h $t^{h'}$	d^h $d^{h'}$	t t'	d d'
k^h $k^{h'}$	g^h $g^{h'}$	k k'	g g'

b) Progressive dialect

Radical ⇒	Eclipsed	Radical ⇒	Eclipsed
p^h	b	p	b
t^h $t^{h'}$	d d'	t t'	d d'
k^h $k^{h'}$	g g'	k k'	g g'

The two varieties of Applecross Gaelic present a minimal distinction between the preservation and loss of aspiration under eclipsis. The case of the progressive dialect, where aspiration is not retained on voiced stops, is a reflection of the markedness of voiced aspirates. In the conservative dialect, STAY[spread glottis] must outrank the markedness constraint *VOICED ASPIRATE (and RESIST[spread glottis], since M takes on this value). In the progressive dialect, either RESIST[spread glottis] or *VOICED ASPIRATE must outrank STAY[spread glottis]. Tableau (33) illustrates the ranking in the conservative dialect of STAY[spread glottis] over *VOICED ASPIRATE and RESIST[spread glottis].

(33) Conservative dialect ranking: aspiration retained

M + t^h	STAY [spread glottis]	RESIST [spread glottis]	*VOICED ASPIRATE
d	*!		
√ d^h		*	*

The aspirated /t^h/ in (33) coalesces with the M morpheme, yielding a voiced stop (since prenasalized stops are ruled out here, as in Irish). The first candidate, which is a plain (and therefore less marked) voiced stop is ruled out because it is unfaithful to the [spread glottis] feature of the /t^h/. The more marked second candidate wins, since it retains the [spread glottis] feature, even though realizing the aspiration on the output correspondent of M violates RESIST [spread glottis].

It can easily be seen by inspecting the tableau that the promotion of either RESIST[spread glottis] or *VOICED ASPIRATE would result in the absence of voiced aspirates under eclipsis. Candidate (b) in (33) violates both RESIST [spread glottis] and *VOICED ASPIRATE, so if either of these constraints were top-ranked in tableau (33) candidate (b) would lose and candidate (a) would win. This alternative ranking characterizes the progressive dialect in Applecross. By the ranking of either RESIST [spread glottis] or *VOICED ASPIRATE over STAY [spread glottis] the plain voiced stop becomes the optimal output for the eclipsis of an aspirated voiceless stop.

The ranking in tableau (33) and the ranking in tableau (29) (which showed the derivation of prenasalized stops in Gaelic) are similar in that they allow the derivation of marked segments. In both the prenasalization cases and the aspiration retention cases a segment is derived under eclipsis that does not occur otherwise in the language. The voiced stops of Applecross Gaelic also occur only as the result of eclipsis: unmutated stops are all voiceless. Consonant mutations are sometimes permitted to derive segments that are otherwise ruled out in a language. This is not always the case: eclipsis of *s* fails in Irish and Gaelic due to a prohibition on *z*. Nevertheless, the mutations can sometimes expand the permitted segment inventory. The fact that voiced stops, voiced aspirates and prenasalized stops are otherwise ruled out in Gaelic means that the markedness constraints disallowing them are ranked below the faithfulness constraints which preserve them. The constraint hierarchy must nonetheless rule out other cases of output voiced stops, voiced aspirates, and prenasalized stops, since in Optimality Theory inputs are unconstrained and may contain voiced stops (aspirated or prenasalized). The issue of mutation deriving otherwise excluded segments is returned to and resolved in section 3.4.

To summarize the Gaelic case, Hebridean Gaelic contrasts aspirated and unaspirated voiceless stops, but not voiceless and voiced stops. The stem segments that undergo eclipsis are therefore all underlyingly IV1. The output is a prenasalized stop, realizing the M's IV3 value and bordering on the stem segment's IV1 value. The core ranking responsible for the Gaelic prenasalization is given in (34a). The ranking responsible for the preservation of aspiration (where this occurs) is given in (34b). Although the rankings discussed in this section do not provide a link to the rankings in (34a), the link is shown below in tableau (72) in 3.4.2 and is given below in parentheses.

(34) Summary of Rankings in Gaelic

a) MORPH REAL >> IDENT [IV] >> *PRENASAL

b) STAY [spread] >> RESIST [spread], *VOICED ASP (>> IDENT [IV])

By the ranking in (34a) prenasalized stops are allowed to show up because the markedness constraint ruling them out is ranked below IDENT [IV], unlike in Irish. If *PRENASAL ranks below IDENT [IV], a voiceless stop will prenasalize instead of just voicing, since the prenasalized stop, by realizing the IV3 of the M input incurs fewer IDENT [IV] violations.

3.3.3 Manya Eclipsis: Chain Shift with Prenasalization

The Mande language Manya, spoken in Liberia, has an eclipsis process very similar to that in Gaelic, with the difference that Manya has both voiceless and voiced obstruents in unmutated initial positions. The Manya inventory of unmutated consonants is given in (35), leaving aside those consonants (*p*, *g*, *š* , *z*) which occur extremely rarely, or only in loan words (Heydorn 1943-4).

(35) Manya Radical Consonants

	t		k	
b	ɖ	dy		gb
m	n	ɲ		
f	s			
v				
	l	y		w

All word-initial consonants in (35) other than nasals are subject to eclipsis. The effects of Manya eclipsis are shown in table (36).

(36) Manya eclipsis (Heydorn 1943–4)

Radical ⇒	Eclipsed	Radical ⇒	Eclipsed	No Change
k	^{ŋ}g	gb	^{ŋm}bg	
t	^{n}d	ɖ	n	n
		d^{y}	ɲ	ɲ
		b	m	m
f	v (^{m}v)	v	m	
s	z (^{n}z)	l	n	
		y	ɲ	
		w	w̃	

Eclipsis in Manya occurs in two basic environments. First, it replaces the first person singular pronoun *nẹ́* in possessives, direct objects, and objects of postpositions. The other environment is after a nasalized vowel within an NP or VP. Thus it occurs in verbs when the preceding object ends in a nasalized vowel and in adjectives and numbers when the preceding noun ends in a nasalized vowel. When an adjective begins in *f* or *s* it becomes *mv* or *nz* (instead of *v* or *z*) after a nasalized-vowel-final noun, and the same happens in a noun when it is compounded with another noun. Otherwise the *f* and *s* become *v* and *z*. In all cases of eclipsis after a nasalized vowel the nasalization is lost from the vowel of the preceding word when the initial segment of the next word undergoes eclipsis.

Examples of Manya eclipsis are given in (37).[19]

(37) Manya eclipsis: examples (Heydorn 1943–4)

a) Eclipsis as first person pronoun

tò̲ fé̲	'side, near'	^{n}dò̲ fé̲	'by me'
kílì	'to call'	^{ŋ}gílì	'to call me'
gbásí	'to hit'	^{ŋm}gbásí	'to hit me'
bà	'mother'	má	'my mother'
ɖà	'mouth'	ná	'my mouth'
d^{y}úsò	'heart'	ɲúsò	'my heart'
fé̲	'direction'	vé̲	'to me'
sílì	'to bind'	zílì	'to bind me'
yè̲	'for'	ɲè̲	'for me'
wò ló	'thigh'	w̃ò ló	'my thigh'

b) Eclipsis after nasalized vowel

bọ̃́	'house'	+	ló̲	'to cause to stand'	bọ́ nò̲	'to build a house'
	"	+	bà	'big'	bọ́ mà	'a big house'
	"	+	fílà	'two'	bọ́ vílà	'two houses'
fẹ̃́	'thing'	+	fĩ̀	'to be heavy'	fẹ́ mvǐ	'a heavy thing'
kṹ	'head'	+	sì í	'hair'	kúnzíî	'head hair'

In the eclipsis of (37a) the mutation is clearly morphologically triggered. The first person singular pronoun, which occurs alone as *nẹ́* , has a prefix form that contains only the nasal segment. In order to be syllabified it must coalesce with the stem-initial segment. It therefore behaves much as the underspecified eclipsis morpheme in Irish and Gaelic. In the cases in (36b) the environment is

[19] Heydorn also mentions another environment for eclipsis, namely where the mutating segment is preceded by a nasal in the onset of the previous syllable. Heydorn does not describe the morphological environments in which this occurs, however. He gives only a few examples, and these without morphological analyses. I leave aside this aspect of the mutation.

not clearly morphological. It occurs in certain syntactic and morphological domains, but it is clearly triggered by a phonological property of the preceding word, associated with the nasalization on its vowel. The nasalization is not inextricably linked to the vowel, since it disappears when a following consonant mutates. The fact that the nasalization can be realized on the vowel or as mutation on the following consonant suggests that the nasalization is due to the effects of a 'floating' nasal rather than to an inherent property of the vowel. The floating nasal, I propose, is associated with an IV3 value, and as such constitutes an underspecified segment of the type considered in Irish and Gaelic. In the absence of a following word within its phrase, the underspecified (or floating) segment will coalesce with the word-final vowel, causing nasalization. When a word follows, the nasal will show up on it, by causing eclipsis of the initial consonant. When eclipsis occurs on the next consonant, the vowel does not nasalize.

In this nasal vowel/eclipsis alternation, the underspecified segment needs a way to have an output correspondent, and so satisfy MAX. Possible ways to have an output correspondent include coalescence with the preceding vowel, coalescence with the following consonant, and epenthesis of enough structure to support a full segment. The first two of these occur in Manya, while the third does not, due to a high ranking NOCODA.[20] Tableau (38) shows the nasalizing of a word-final vowel which is followed by an underspecified segment containing IV3 and [nasal]. (I abbreviate the segment as N, not M, to emphasize that it is different from the purely morphemic eclipsis M.) In order for N to avoid deletion, it must coalesce with the vowel. The vowel violates RESIST[nasal] and

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[20] Heydorn does not explicitly state that codas are disallowed in Manya, but the generalization can be made on the basis of the forms he cites. Furthermore, he proposes that Manya nasalized vowels are derived from earlier vowel + nasal sequences, and shows that this can be supported with vowel + nasal cognates from Vai. The loss of the coda nasals would be due to the promotion of the NOCODA constraint.

also the markedness constraint which outlaws nasalized vowels. The RESIST[nasal] and *NASAL-VOWEL constraints must be lower ranked than NO-CODA, which would be violated by the N showing up, with epenthesized features, after the vowel.

(38) Final nasal must show up on vowel

$C\ a_1\ N_2$	MAX	NO-CODA	STAY [nasal]	RESIST [nasal]	*NAS-VOWEL
a. $C\ a_1$	*!				
b. $C\ a_{1,2}$			*!		
c. $C\ a_1 n_2$		*!			
d. √ $C\ \tilde{a}_{1,2}$				*	*

In tableau (38) the first candidate fails because the N segment has been deleted, violating MAX. In the second candidate the N segment has not been deleted, but the vowel has not taken on its [nasal] feature. It violates STAY [nasal], fatally. In the third candidate the input nasal segment corresponds to an independent output segment, fatally violating NO-CODA. This leaves the final candidate as the winner. It violates RESIST [nasal], since the vowel has taken on the [nasal] feature, and it violates *NASAL-VOWEL, but these are lesser violations than those the other candidates commit.

If a consonant-initial word follows, the N prefers to coalesce with the consonant instead of with the vowel. The consonant will violate IDENT [IV] and, sometimes *PRENASAL. This demonstrates that *NASAL-VOWEL dominates IDENT [IV] and *PRENASAL in Manya. A coalescence of N with *k* yields ᵑ*g*, with a IDENT [IV] violation and a *PRENASAL violation. This is shown in tableau (39).

(39) Eclipsis wins over vowel nasalization

C a_1 N_2 k_3	*NAS-VOWEL	*PRENASAL	IDENT-ADJ
$\tilde{a}_{1,2}$ k_3	*!		
√ a_1 $ŋg_{2,3}$		*	*

In the first candidate in tableau (39) the vowel is nasalized, as is the winner from tableau (38). This candidate does not win in this case, however, because there are further candidates not available in tableau (38). In (39) the N is followed by a consonant. It can therefore coalesce with either the consonant or with the vowel. Coalescing with the consonant is the preferred option. Violating IDENT [IV] and *PRENASAL is less serious than violating *NASAL-VOWEL, so the second candidate wins.

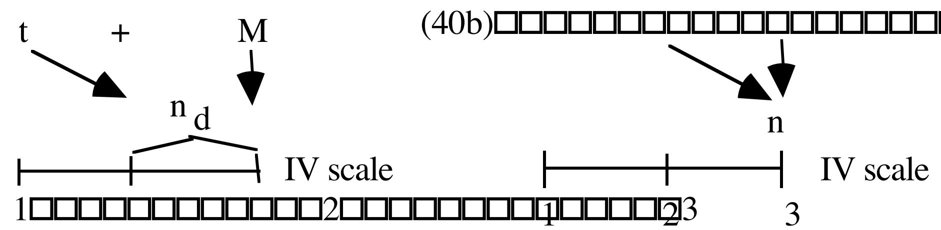
To summarize the Manya case so far, Manya eclipsis occurs morphologically as coalescence with the first person singular pronoun, and phonologically as coalescence with a word-final nasal segment within a certain type of phrase. In the absence of a following word, the word-final nasal segment will coalesce with the vowel of its own word. In the presence of a following consonant-initial word the nasal segment coalesces with the consonant. The phonological coalescence can be analyzed as driven simply by MAX and STAY [nasal], without the need to invoke the (here irrelevant) MORPH REAL.[21] I turn now to the particular output forms that Manya eclipsis takes on, putting aside the source (morphological or phonological) of the coalescence.

[21] In Manya, where eclipsis is fully phonological and not morphological, MAX must be the constraint that forces the nasal to show up. The question arises whether the other (morphologically driven) cases of eclipsis could be driven by MAX too, thus getting rid of MORPH REAL. This solution does not work, since MAX is satisfied even in invisible coalescence. What makes the coalescence visible in Manya is the STAY [nasal] constraint: all the outputs of the coalescence are nasal. In languages such as Irish the case is different, since no one feature or scale value of the M morpheme always shows up. Cases like Irish require the MORPH REAL constraint.

In Manya, as in Hebridean Gaelic but unlike in Irish, the voiceless obstruents (the stops generally and sometimes the fricatives) do more than just voice. They nasalize, yielding prenasalized segments. In so doing the mutation outputs are faithful to the [nasal] and IV3 features of the eclipsis segment. Since the prenasalized segments are both IV3 and IV2, an output prenasalized stop is adjacent to the input IV1 of a stem-initial voiceless obstruents, and also coincides with the input IV3 of M. The prenasalization of Gaelic and Manya is therefore a more faithful way of coalescing M with a voiceless obstruent than is the simple voicing seen in Irish.

Unlike in the Gaelic case, this more faithful eclipsis can not be brought about through the ranking of IDENT [IV] over *PRENASAL. IDENT [IV] violations are not minimized at the cost of *PRENASAL violations, as the voiced obstruents show. The voiced obstruents (leaving aside *gb* for the moment) all become plain nasal stops. The basic pattern of Manya eclipsis is illustrated in (40).

(40a) (40b)



In both (40a) (voiceless obstruents) and in (40b) (voiced obstruents) the stem segments incur an IDENT [IV] violation in eclipsing. As the first candidate in tableau (41) shows, however, the voiced obstruents could have avoided an IDENT [IV] violation by simply prenasalizing. Since the first candidate loses we can conclude that Manya considers a prenasalized stop worth avoiding if it can do so without causing a IDENT [IV] violation. The eclipsis of Manya voiced stops is given in (41), which shows that *PRENASAL outranks IDENT [IV]. For simplicity only coalesced candidates are given.

(41) Voiced stops become nasal sonorants in Manya

/ M + b /	*PRENASAL	IDENT [IV]
ᵐb	*!	
√ m		*

In (41) the plain *m* wins because it avoids a *PRENASAL violation while incurring only a IDENT [IV] violation. The voiced obstruents therefore become plain nasals in Manya.

As (41) shows, voiced obstruents avoid violating *PRENASAL, which is high ranking in Manya. Why then do the voiceless stops prenasalize? As the eclipsis chart in (36) shows, all eclipsis outputs in Manya (except the *v* and *z*) are nasal to some degree or another. As tableau (38) demonstrated in the case of nasalizing vowels, STAY [nasal] must be highly ranked in Manya. Thus the voiceless obstruents become prenasals because they must keep the M's [nasal] feature, and they can not become plain nasals without violating IDENT-ADJ [IV].[22] STAY [nasal] must outrank the *PRENASAL constraint in Manya, while *PRENASAL outranks IDENT [IV]. The eclipsis of voiceless /k/ is given in tableau (42) (as usual, considering only coalesced candidates).

(42) Voiceless stops prenasalize in Manya eclipsis

/ M + k/	IDENT-ADJ [IV]	STAY [nasal]	*PRENASAL	IDENT [IV]
g		*!		**
ŋ	*!			
√ ᵑg			*	*

[22] This may actually be the reason for prenasalization in Hebridean Gaelic, too, but since there are no radical voiced obstruents it is impossible to tell.

In (42) ŋ is out because it violates IDENT-ADJ [IV]. ᵑ*g* and *g* are both adjacent moves for the /k/ to take. The more marked ᵑ*g* is chosen over the less marked *g* because it is faithful to the M's [nasal] feature.

To summarize the eclipsis of Manya obstruents, obstruents are allowed to take one step on the IV scale to accommodate M, but not two, as in the other languages examined so far. So the voiceless stops can not become nasal sonorants because a move to IV3 is simply too big a step from IV1. They must become prenasalized stops instead, since they must also preserve the M's [nasal] feature. Voiced obstruents become plain nasals, since this requires taking only one step on the scale, and it avoids the marked prenasalized stops. Tableau (42) showed the derivation of prenasalized stops from voiceless stops, while (43) shows the derivation of nasal sonorants from voiced stops, expanding on the ranking in tableau (41).

(43) Voiced obstruents become plain nasals

M + b	IDENT-ADJ [IV]	STAY [nasal]	*PRE-NASAL	RESIST [nasal]	IDENT [IV]
a. b		*!			
b. ᵐb			*!	*	
c. √ m				*	*

In (43) the prenasalized stop is not chosen as the eclipsis output for a voiced stop, although it is the output for a voiceless stop in tableau (42). The plain nasal is chosen instead because it does not violate *PRENASAL, and only violates IDENT [IV].

Tableaux (42) and (43) illustrate a further reason why it is necessary to have two separate constraints IDENT-ADJ [IV] and IDENT [IV] rather than a single gradient faithfulness constraint. Having two constraints allows constraints to be ranked in between them. *PRENASAL crucially ranks between IDENT-ADJ [IV] and

IDENT [IV] in Manya, demonstrating that they must be two separate constraints, and not a single gradiently evaluated faithfulness constraint. The generalization to be made here is that a segment can be forced to take on a marked value (here a prenasalized stop) if the less marked alternative (a plain nasal) is too far away on the scale.

An exception to the pattern that voiced stops become plain nasals is the behavior of *gb*, which prenasalizes to ^{ŋm}*gb*. If *gb* behaved as other voiced stops we would expect ŋ*m*. The key to this idiosyncratic behavior, I propose, lies in a constraint on ŋ (and hence on ŋ*m*). First of all, ŋ does not occur in the non-eclipsed inventory of Manya. Even under eclipsis, ŋ only occurs as the first half of a prenasalized stop (in ^{ŋ}*g* and ^{ŋm}*gb*[23]). It can be concluded, therefore, that Manya does not allow ŋ except when it is the nasal half of a prenasalized stop. (The exception for prenasalized stops may be because place features are linked to the stop portion of a prenasalized stop, rendering ŋ in ^{ŋ}g unrecognizable as velar.) Tableau (44) shows the effect of a *ŋ constraint in the hierarchy. *ŋ is violated only by fully nasal ŋ.

(44) ŋ disallowed as eclipsis output in Manya

M + gb	*ŋ	*PRENASAL
ŋm	*!	
√ ^{ŋm}gb		*

By tableau (44) the fully nasal ŋ is ruled out, and the prenasalized stop appears instead. Because of the *ŋ constraint, *gb* behaves differently under eclipsis than other voiced stops, becoming a prenasalized stop rather than a plain nasal sonorant.

[23] Heydorn (1943–44) actually transcribes ^{ŋm}*gb* as *ṁ gb*, leaving the place of articulation of the nasal portion somewhat unclear.

Unlike in Irish or Gaelic, the (non-nasal) sonorants in Manya undergo eclipsis. Since sonorants already have an IV3 value, the only way they can undergo eclipsis is by becoming nasal. As for the glides, *y* becomes ɲ. To do so it must violate STAY CS3, which demands that the vocoidal stricture of the glide be maintained. By contrast, *w* becomes *w̃* , without losing the CS3 value. Why the difference between them? I propose that here again are the effects of the *ŋ constraint. If the *w* became a nasal stop, it would become ŋ*m* or ŋ, which are ruled out by the *ŋ constraint. In the case of the *y*, it can become a straightforward nasal stop, since ɲ is already allowed in Manya and occurs in radical as well as eclipsed environments. The conclusion is thus that becoming a nasal stop is preferable to becoming a nasalized glide, but that the *w* is prohibited from becoming a stop due to the *ŋ constraint. The eclipsis of *y* and *w* is shown in the tableaux in (45).

(45) Eclipsis of glides in Manya

a) *y* becomes ɲ

M + y	MORPH REAL	*ŋ	*Nasal Glide	STAY CS3
y	*!			
ỹ			*!	
√ ɲ				*

b) w becomes w̃

M + w	MORPH REAL	*ŋ	*Nasal Glide	STAY CS3
w	*!			
√ w̃			*	
ŋ		*!		*

As the tableau in (45a) shows, a nasal stop is the preferred outcome of coalescence between M and a glide. As (45b) shows, however, a nasalized glide will appear instead if the nasal stop is independently ruled out. In the case of the *w*, the corresponding stop (ŋ or ŋ*m*) is ruled out by a high-ranking constraint, and so the nasalized glide is the best remaining option.

The lateral *l* also undergoes eclipsis, losing its continuance (CS2) and its [lateral] features to become a nasal stop *n*. Unlike in Irish, STAY CS2 and STAY [lateral] do not rank highly enough in Manya to prohibit eclipsis of *l*. *l* is not the only segment that loses its CS2 value: the *v* becomes *m*, independently establishing that STAY CS2 is dominated by MORPH REAL.[24] This is shown in tableau (46).

(46) *l* becomes *n* under Manya eclipsis

M + l	MORPH REAL	STAY CS2	STAY [lateral]
l	*!		
√ n		*	*

By the ranking of MORPH REAL over STAY CS2 and STAY [lateral], *l* undergoes eclipsis and becomes *n*, realizing the eclipsis morpheme and satisfying the high-ranking STAY [nasal].

To summarize the Manya case, Manya eclipsis occurs in a morphological environment (coalescence with the first person pronoun, M) and in a phonological environment (coalescence with a floating nasal segment, N). STAY [nasal] is high-ranking, so the coalescence will be visible for all segments except nasals (regardless of whether MORPH REAL or MAX is enforcing the coalescence). Voiceless stops become prenasalized stops. This satisfies STAY [nasal], but avoids violating the highly-ranked IDENT-ADJ [IV]. Voiced obstruents generally become plain nasals. They can avoid the marked prenasalized stops by violating only IDENT [IV]. The core ranking that derives the eclipsis of voiceless and voiced stops in Manya is given in (47a). An exception to the pattern of voiced stops

[24] In the case of the non-morphemic coalescence with the floating nasal, STAY CS2 would be dominated by STAY [nasal] and MAX.

nasalizing is *gb*, which prenasalizes to $^{\eta m}gb$ to avoid the ŋ which would be created if the *gb* nasalized to ŋ*m*. The eclipsis of *gb* is accomplished by the ranking in (47b). The non-nasal sonorants also become nasal. *y* becomes ɲ. The *w* can not become ŋ, due to *ŋ, so it becomes *w̃*. The eclipsis of glides is governed by the constraint ranking in (47c). The *l* becomes *n*, by the ranking in (47d).

(47) Summary of Constraint Rankings in Manya

a) MORPHREAL, MAX, STAY[nas], *NON-ADJ>> *PRENASAL >> IDENT [IV]
b) *ŋ >> *PRENASAL
c) MORPH REAL, *ŋ, >> *Nasal Glide >> STAY CS3
d) MORPH REAL >> STAY CS2 >> STAY [lateral]

The interaction between faithfulness constraints (IDENT [IV], IDENT-ADJ [IV] and featural faithfulness constraints such as STAY [nasal]) and various markedness constraints (*PRENASAL, *Nasal Glide, *ŋ) determine the course of the eclipsis. Because of this constraint interaction, different segments respond differently to eclipsis, even within a single language.

3.3.4 Welsh: Full Nasalization

Welsh numbers an eclipsis process (traditionally know as the nasal mutation) among its several consonant mutations (Ball & Müller 1992).[25] Unlike the languages analyzed so far, Welsh has no chain shift and produces only nasal sonorants as the result of eclipsis. In spite of this difference, Welsh can be analyzed in the same pattern as the languages discussed above. Word-initial radical consonants are shown in (48). The occurrence of the fricatives in brackets in word-initial radical form is restricted to loans and fossilized mutated forms.

[25] I follow Ball & Müller in restricting my attention to Standard Welsh except where noted. For other treatments of Welsh mutation see Awberry (1975), Griffen (1976) and Grijzenhout (1995).

(48) Radical Initial Consonants in Welsh

p^h	t^h	k^h
p	t	k
m	n	
f (v)	(θ) (ð) s	x
	ɬ r^h	h

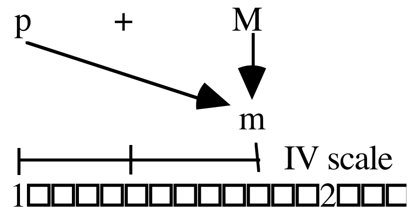
The two stop classes are traditionally termed 'fortis' and 'lenis' or 'voiceless' and 'voiced'. However, acoustic studies show that very little or no voicing occurs in the 'voiced' series. The reliable difference between these classes is one of aspiration (Ball 1984, Ball & Müller 1992). The nasal mutation has the following effects.

(49) Eclipsis in Welsh

Radical ⇒	Eclipsed	Radical ⇒	Eclipsed	No Change
p^h	m^h	p	m	f m
t^h	n^h	t	n	s n ɬ r^h
k^h	ŋ^h	k	ŋ	h

The nasal mutation is triggered by the first person singular genitive pronoun, the preposition *yn* 'in', certain cardinal numbers, and the lexical items *blwydd* 'year old', *blynedd* 'years' or *diwrnod* 'day' when they are themselves followed by one of those cardinal numbers or the numeral *un* 'one' in a compound number. The derivational affixes *ang*- (negative) and *cyng*- ('con-') also trigger nasal mutation.

The interesting aspect of Welsh eclipsis is that the voiceless stops do not become voiced (or voiced prenasalized), but become full nasals, moving two steps on the IV scale. The long-distance movement in Welsh is shown in (50).

(50) 

In moving to IV3 the Welsh voiceless stops violate IDENT-ADJ [IV]. Since IDENT-ADJ [IV] is universally ranked above IDENT [IV], we would expect (other things being equal) only the lower-ranked IDENT [IV] violations, as in the other languages considered so far. There must be some other constraint(s) at work which force violation of the higher-ranked IDENT-ADJ [IV]. A good candidate for this constraint is one that rules out voiced obstruents. In Welsh the unaspirated stops are often fully voiceless, although a little bit of voicing sometimes occurs. If that little bit of voicing that sometimes accompanies the unaspirated series can be considered phonetic and not phonologically specified, then Welsh can be said to have no voiced stops. This means that *VOICED STOP (or just *IV2) is highly ranked.[26] The faithfulness constraint STAY IV2 is ranked below *IV2, with the result that an input voiced stop would be devoiced in the output. The same is true of Hebridean Gaelic where the unmutated stops were all voiceless. Unlike Gaelic, however, Welsh is not allowed to create voiced or prenasalized stops in the mutation process either. The stops must move two steps on the IV scale, violating IDENT-ADJ [IV] in order to avoid voiced stops and voiced prenasalized stops, both of which contain an IV2 specification. In moving two steps on the IV scale Welsh creates marked aspirated nasals from the aspirated voiceless stops,

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[26] See Chapter 4 for a more thorough discussion of markedness constraints which refer to the scale values. The general *IV2 constraint can be used, since 'voiced' and 'voiceless' fricatives in Welsh are not actually distinguished by voicing. 'Voiced' fricatives have little or no voicing. The distinction between the two classes is that the 'voiceless' fricatives are longer than the 'voiced' fricatives. It can be concluded, therefore, that IV2 segments in general (not just stops) are ruled out in Welsh.

just as Applecross Gaelic created the marked voiced aspirates. This is due to a high ranking faithfulness constraint on the aspiration, as shown in tableau (51).

(51) IDENT-ADJ [IV] violated in Welsh eclipsis

a) Plain voiceless becomes plain nasal

M + t	MORPH REAL	*IV2	STAY [spread]	IDENT-ADJ [IV]	IDENT [IV]
$t_{1,2}$	*!			*	
d		*!			*
√ n				*	

b) Voiceless aspirate becomes nasal aspirate

M + t^h	MORPH REAL	*IV2	STAY [spread]	IDENT-ADJ [IV]	IDENT [IV]
$t^h{}_{1,2}$	*!			*	
$d_{1,2}$		*!	*		*
$d^h{}_{1,2}$		*!			*
$n_{1,2}$			*!	*	
√ $n^h{}_{1,2}$				*	

In (51a) the voiced obstruent fails as a candidate for the eclipsis output of /t/, because it is a voiced obstruent, which Welsh disallows by the high ranking of *IV2. IDENT-ADJ [IV] is violated instead. Although the ranking between IDENT-ADJ [IV] and IDENT [IV] alone would predict only adjacent movement on the scale, the high ranking of the *IV2 constraint forces violation of IDENT-ADJ [IV]. Although consonant mutation tends to proceed by short hops (due to the ranking of IDENT [IV] below IDENT-ADJ [IV]), longer steps on the scale may be taken if the small hop is ruled out due to markedness constraints. Welsh is just such a case. Instead of the compromise seen in other languages of M + IV1 becoming IV2 or IV2-3, in Welsh it goes all the way to IV3, since IV2 is independently ruled out.

Another way of looking at the Welsh case is to say that the outputs must be nasal for some other reason: either because the M contains only [nasal] and not IV3, or because it contains both, and STAY [nasal] is highly ranked. The former may be true, but I do not pursue it, it order to present a unified analysis of eclipsis as caused by an M morpheme containing IV3.[27] The latter case would be like Manya, except that *PRENASAL would also be highly ranked, so that eclipsis outputs must be fully nasal, not just prenasalized. This solution will not work, however. STAY [nasal] must be dominated by the constraint forbidding aspirated nasals. In the case of an underlying aspirated nasal, either the nasality or the aspiration must be lost, since Welsh does not allow aspirated nasals in non-mutation contexts. From the effects of STAY [spread] in (51), we know that STAY [spread] outranks the constraint against nasal aspirates, since nasal aspirates are created due to STAY [spread]. Underlying nasal aspirates must therefore denasalize, and STAY [nasal] must be the constraint that gets violated. STAY[nasal] therefore can not rank highly enough to force the aspirated stops to nasalize and become aspirated nasals. The ranking responsible for the ruling out of unmutated nasal aspirates is discussed further in 3.4.3. As in Gaelic, Welsh eclipsis derives segments (here aspirated nasals) that are not otherwise permitted in the language. This issue is addressed in section 3.4. Since the *IV2 constraint is not violated at all, I use it to force the IDENT-ADJ [IV] violations in Welsh.

The fricatives and liquids in Welsh do not undergo eclipsis. In order for the fricatives to realize the eclipsis morpheme, they would have to voice or become nasal. They do not voice, yielding further evidence that *IV2 is in fact ranked above MORPH REAL. They do not become nasals, since this would involve becoming stops (assuming nasal fricatives are ruled out). The liquids, too, would

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[27] It is possible that the [nasal] feature always requires the presence of IV3, since [nasal] is very often associated with voicing (an IV phenomenon).

have to mutate by becoming stops. Since this does not happen, we can conclude that STAY CS2 is ranked above MORPH REAL. The failure of eclipsis in fricatives and liquids is shown in (52).

(52) Failure of liquids and fricatives to undergo eclipsis in Welsh
a) liquids are unchanged

M + r^h	STAY CS2	*IV2	MORPH REAL
√ r^h			*
n^h	*!		

b) fricatives are unchanged

M + s	STAY CS2	*IV2	MORPH REAL
√ s			*
z		*!	
n	*!		

The tableaux in (52) demonstrate that liquids and fricatives in Welsh can not undergo eclipsis because the eclipsis morpheme can not be realized. For a liquid or a fricative to become a nasal would require the loss of the CS2 specification. This does not happen since STAY CS2 outranks MORPH REAL. Voicing the fricative would violate *IV2, which also outranks MORPH REAL.[28]

To summarize the Welsh case, Welsh stops move two steps on the IV scale, becoming nasal stops, and retaining any aspiration. The long movement violates IDENT-ADJ [IV], but this is required by the constraint *IV2, which disallows IV2 as a landing spot. The core ranking for Welsh is given in (53a). The retention of aspiration occurs by the ranking in (53b). As will be shown below in tableau (74) in Section 3.4.3, *NASALASP is ranked above IDENT-ADJ [IV].

[28] Alternatively, voicing the fricative can be seen as a useless attempt at eclipsis if the eclipsis morpheme contains only [nasal].

Fricatives and liquids do not undergo eclipsis, since they are not allowed to lose their CS2 specification in order to become nasals. The ranking is shown in (53c).

(53) Summary of Rankings in Welsh

a) *IV2 >> MORPH REAL >> IDENT-ADJ [IV] >> IDENT [IV]

b) STAY [spread] >> RESIST [spread], NASALASP

c) STAY CS2 >> MORPH REAL

An alternative analysis to the ranking in (53a) would be that the long movement is required because the eclipsis morpheme contains only [nasal], which would require the mutation output to be nasal. Given a high-ranking *PRENASAL, the mutation output would be required to be a simple nasal sonorant (violating IDENT-ADJ [IV]) and not a prenasalized stop (violating only IDENT [IV]). In this case, the eclipsis would take its shape from the high ranking of *PRENASAL, not *IV2. In either case Welsh eclipsis demonstrates that although small movements on the scale (violating IDENT [IV]) are preferred over large jumps (violating IDENT-ADJ [IV]), the large jump can be taken when the small movement is ruled out by other constraints.

3.3.5 Fula: No IV Movement.

The West Atlantic language Fula provides an example of an eclipsis pattern that rounds out the typology presented here. Irish, Gaelic and Manya provide examples of short-distance movement on the IV scale under eclipsis, while Welsh provides an example of long-distance movement. Fula, on the other hand, has an eclipsis process that involves no IV movement at all.

In Fula a noun stem begins with a consonant belonging to one of three grades, depending on what class the noun falls into. The class of the noun is determined by the suffixes on the stem (Anderson 1976a, Arnott 1970).[29] These are given in (54) for the Gombe and Adamawa dialects.

(54) Consonant grades in Fula

A 'Continuant'	B 'Stop'	C 'Nasal'	Unaffected
f	p	p	
s	c / š	c / š	t
h	k	k	ʔ
w	b	^{m}b	m, ɓ
r	d	^{n}d	n, l, ɗ
y + front V	j	^{n}j	n^{y}, ʔ^{y}
y + back V	g	^{ŋ}g	ŋ
w	g	^{ŋ}g	

Examples of the alternation are given in (55) (from Anderson 1976a, citing Arnott 1970).

(55) Examples of Fula consonant gradation.

a. dim-o '(free) man'
   rim-ɓe '(free) men'
   ndim-a '(free) big men'

b. waa-ndu 'monkey'
   baa-ɗi 'monkeys'
   mbaa-kon 'little monkeys'

c. gim-do 'person'
   yim-ɓe 'persons'
   ŋgim-ŋga 'big person'

d. gor-ko 'man'
   wor-ɓe 'men'
   ŋgor-ga 'big man'

[29] I restrict my attention here to the mutation in stems, although suffixes have a similar pattern. For other analyses of Fula gradation, see Skousen (1972), Lieber (1984, 1987) and Paradis (1992).

e. yardu-de 'calabash'
jardu-ɗe 'calabashes'
njardu-ga 'big calabash'

f. finor-du 'jar for antimony'
pinor-di 'jars for antimony'

g. hufinee-re 'cap'
kufinee-je 'caps

The part of the alternation that is of interest here is the relationship between the B ('stop') and C ('nasal') grades. A voiceless stop remains a voiceless stop and a voiced stop becomes a prenasalized stop.

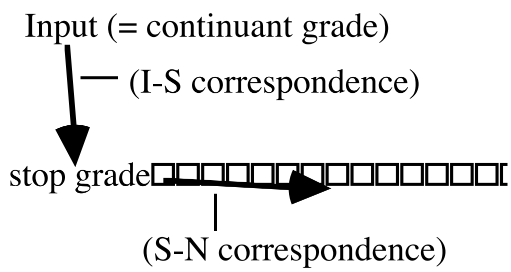
The derivation of the C ('nasal') forms from the B ('stop') forms requires some justification. Although historically the B ('stop') grade was underlying (and underwent a lenition and nasalization mutation similar to those in the Celtic languages), Anderson (1976a) argues that the A ('continuant') grade is underlying in the modern language and now undergoes fortition to derive the stop grade. I would propose, however, that although the stop grade may be indeed derived from the continuant grade, the C ('nasal') grade is in turn derived from the stop grade. In traditional terms this means that there are two cycles, one which derives the stop grade, and a second one which derives the nasal grade.

Within Optimality Theory the two cycles can be derived simultaneously, with the nasal grade in a correspondence relation with the stop grade, which is in a correspondence relation with the continuant grade (which Anderson argues is the same as the input).[30] The use of multiple correspondence relations between multiple morphemic levels follows Benua's (1995, 1996) theory of transderivational identity (which builds on identity effects explored by

[30] Within OT the continuant grade need not be underlying, since inputs are not constrained. Constraints on the output of the input-continuant relation will ensure that the continuant grade will be derived.

McCarthy & Prince (1995)). The faithfulness constraints which require identity between one output grade (here the nasal grade) and the other output grade (here the stop grade) are separately rankable from the faithfulness constraints which require identity between the base output grade (here the stop grade) and the input. The correspondence relations are pictured in (56).

(56) Correspondence between grades in Fula



The picture in (56) complicates the morphophonology with multiple correspondence relations, however, this move can be justified.[31] For one thing, historically the nasal grade was derived from the stop grade, not the continuant grade. The inversion of the lenition process into a fortition did not, I propose, provide the language with any way of deriving the nasal grade from the continuant grade, so the nasal grade has continued to be derived from the stop grade.

The second line of evidence comes from the behavior of stems which do not show the full alternation of all three grades. While many stems show the full alternation among continuant, stop and nasal (where this is different from the stop), a 'substantial number of forms' (Anderson 1976a, p 109) lack the

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[31] Verb stems behave somewhat differently than nouns, in that many verb stems only alternate between the continuant and the nasal grade. A few, however, alternate between stop and nasal grade. In the former case doubly-affixed forms exist without singly-affixed forms, so that two affixes must be added at once. In the latter case singly-affixed and doubly-affixed forms exist without the non-affixed forms, so that the stem and the first affix must be introduced simultaneously. (This is analogous to modern English forms like *uncouth*, which occur without the unaffixed form.)

continuant grade, but alternate between the stop and the nasal grade. Examples are shown in (57).

(57) Stems with missing continuant grade in Fula

a.	daag-o	'sleeping mat' (continuant expected)
	daag-el	'little sleeping mat'
	ndaag-on	'little sleeping mats'
b.	juul-ɗo	'Moslem'
	juul-ɓe	'Moslems' (continuant expected)
	njuu-ŋga	'big Moslem'

As the examples in (57) demonstrate, the nasal grade can be derived from the stop grade in the absence of a continuant grade.[32] It is my claim that the nasal grade is in fact always derived from (or simultaneous with) the stop grade. If this were not the case, it would be difficult to explain why the sonorant continuants (which become voiced stops in the stop grade) become prenasalized stops in the nasal grade. If a nasal stop were wanted, why should the sonorants become prenasalized stops and not just plain nasal sonorants? If the voiced stop is the starting point, the prenasalization makes sense as a way of remaining faithful to the IV2 value of the voiced stop.

I assume, then, that the nasal grade is derived from the stop grade. The alternation of interest, is therefore one in which voiceless stops remain voiceless and (non-glottalized) voiced stops become prenasalized in the environment of an eclipsis M morpheme. On the IV scales, the IV1 voiceless stops remain IV1, while the IV2 voiced stops remain IV2, with the addition of IV3, as shown in (58).

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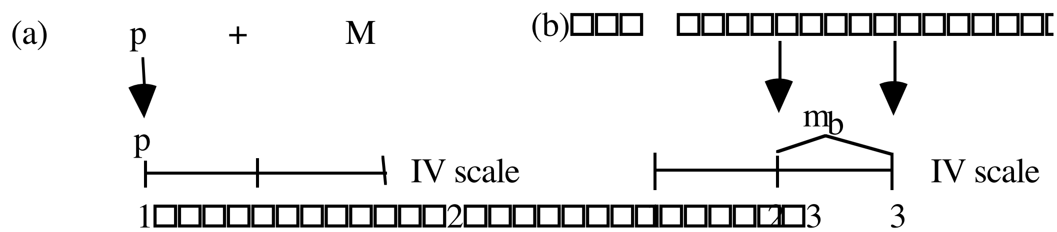
[32] A further point is that stems which fail to show a stop grade where expected, remaining continuant in the stop grade, will also remain continuant in the nasal class. Thus, if the stop grade can not be derived, the nasal grade can not either. These stems with invariant continuants are largely recent loanwords, however.

(58) Effects of M in Fula



In (58a) and (b) no movement takes place on the scale at all. The stem segments are not permitted to leave their input values. MORPH REAL must rank particularly low in this language, below IDENT [IV] (i.e. the IDENT [IV] on the stop grade-nasalgrade relation). This ranking has the effect of not allowing movement on the IV scale as a way of satisfying MORPH REAL.

Consider the case of the voiced stop. It does not leave its input IV2 value, but it is able to realize the M morpheme by becoming prenasalized. This is shown in tableau (59).

(59) Voiced stops prenasalize in Fula

$M_1 + d_2$	IDENT-ADJ [IV]	IDENT [IV]	MORPH REAL
a. $d_{1,2}$		*!	*
b. $n_{1,2}$		*!	
c. √ $^{n}d_{1,2}$			

In (59a) the /d/ has coalesced with the M, and the *d* has not moved on the IV scale, remaining *d*. This violates IDENT [IV] for the M, however, since M is IV3. Candidate (a) therefore fails. In candidate (b) the *d* has moved, becoming *n*. Now the M's IV3 value is faithfully realized, but IDENT [IV] is violated for the /d/. Candidate (c) realizes both the /d/'s IV2 value and the M's IV3 value, so it satisfies MORPH REAL while not violating IDENT [IV] at all. Candidate (c), with a prenasalized output, is therefore the winner.

The case of the voiceless stops is somewhat different. Here we can assume that a *voiceless* prenasalized stop (faithful to both IV1 and IV3) is ruled out, given the rarity of such segments (Ladefoged & Maddieson 1996). Given the ranking of IDENT [IV] above MORPH REAL, the eclipsis of voiceless stops must fail, as shown in tableau (60).

(60) Voiceless stops fail to undergo eclipsis in Fula

$M_1 + p_2$	IDENT-ADJ [IV]	IDENT [IV]	MORPH REAL
a. $m_{1,2}$	*!		
b. $^{m}b_{1,2}$		*!	
c. $p_{1,2}$	*!		*
d. √ p_2			*

In (60a) the /p/ and the M coalesce to yield *m*. This coalescence fails, however, because it incurs a violation of IDENT-ADJ [IV] for the /p/. In (b) the coalescence yields a prenasalized stop. In this case, however, the prenasalized stop also fails. This is because as IV2-3 it violates IDENT [IV] for the /p/, and IDENT [IV] is ranked above MORPH REAL in Fula. Candidate (c) coalesces to *p*. This candidate fails, too, since it violates IDENT-ADJ [IV] for the M. The winning candidate in (d) does not coalesce at all. The M is deleted. The deletion of M violates MORPH REAL, but it does not violate the higher ranked IDENT [IV] or IDENT-ADJ [IV]. The eclipsis therefore fails in the case of the voiceless stop.

To summarize, eclipsis in Fula is very limited, due to the ranking of IDENT [IV] (and therefore also IDENT-ADJ [IV]) over MORPH REAL, as shown in (61).

(61) Summary of Ranking in Fula

IDENT-ADJ [IV] >> IDENT [IV] >> MORPH REAL >> *PRENASAL

By the ranking in (61) no movement on the IV scale can occur to realize the M morpheme. The voiced stops can realize M by becoming prenasalized, thus being faithful to both the IV2 and IV3 values of the two inputs, and incurring no IDENT [IV] violations. The voiceless stops can not realize M at all, since any way of realizing M (voicing, prenasalizing, nasalizing) would violate either IDENT [IV] or IDENT-ADJ [IV]. As a result, voiceless stops fail to become eclipsed.

3.3.6 Summary of Eclipses

At this point a summary of the various eclipsis patterns and their analyses is in order. The first eclipsis pattern to be examined was that of Irish. Irish presents a basic chain shift under certain morphological conditions. Voiceless obstruents become voiced, and voiced obstruents become sonorant nasals. I analyze the triggering morpheme as consisting of an underspecified segment that contains the value IV3, but no other detectable features (although it may contain [nasal]). The underspecified segment must be realized, thanks to the MORPH REAL constraint. Realization of the segment entails coalescence with the intial stem segment. Since each of the two underlying segments has its own IV value, faithfulness constraints must be violated in order for the coalescence to take place and MORPH REAL be satisfied. Since IDENT-ADJ [IV] is highly ranked, it is better to move to an adjacent scale value (violating IDENT [IV]) than to move to a non-adjacent value. The coalescence therefore results in a chain shift pattern. Voiceless obstruents (IV1) coalesce with the IV3 to yield IV2 (voiced obstruents), violating IDENT [IV] twice but satisfying IDENT-ADJ [IV]. Voiced obstruents (IV2) coalesce with IV3 to yield IV3, violating IDENT [IV] just once.

Hebridean Gaelic has no radical voiced obstruents, so there is no chain shift. Voiceless obstruents coalesce with the IV3 morpheme. Instead of simply becoming IV2, however, they prenasalize, taking on the contour IV2–3. In faithfully reproducing M's IV3, the voiceless obstruents incur only one IDENT [IV] violation. This more faithful eclipsis is possible in Gaelic because the constraint against prenasalized stops is lower ranked than in Irish. IDENT [IV] violations are minimized in Gaelic at the cost of creating prenasalized stops, while the opposite is true for Irish.

In Manya, eclipsis is a full chain shift, as in Irish, with prenasalization, as in Gaelic. Prenasalized stops in Manya are avoided where possible, so that voiced obstruents beome nasal sonorants under eclipsis, violating IDENT [IV], just as in Irish. Voiceless stops prenasalize, however. This is analyzed as due to the fact that the eclipsis-inducing segment possesses the value [nasal], and faithfulness to [nasal] is highly ranked. The voiceless stops must therefore become nasal, but because of high-ranking IDENT-ADJ [IV], they may not become full IV3 nasals and must become IV2–3 prenasals instead. The marked prenasalized stops are thus derived when the less marked plain nasals are too far away.

In Welsh no chain shift occurs. As in Gaelic the radical segments are all voiceless. All stops become full sonorant nasals, retaining their aspiration values. Here IDENT-ADJ [IV] is violated. This is due to the dominance of MORPH REAL over IDENT-ADJ [IV], and the fact that IV2 segments are ruled out in Welsh. The IV2 middle ground, which would cause only IDENT [IV] violations is unavailable, so the higher ranked faithfulness constraint is violated.

In Fula, no movement on the IV scale may occur, demonstrating a case of high ranking of IDENT [IV]. Voiced obstruents prenasalize, keeping their IV2 value and M's IV3 value and so avoid violating IDENT [IV]. Voiceless obstruents may not realize M at all without moving on the IV scale, so mutation fails.

As this brief summary shows, various cases of chain-shift-like behavior can be shown to be a response to an IV3 morpheme. The expression of the response is controlled by the relative faithfulness constraints and a few other well motivated constraints.

3.4 Consonant Mutation and the Coalescence Paradox

Many of the languages discussed in the preceding sections are not structure preserving under eclipsis. In other words, segments occur under eclipsis that are not otherwise permitted in the language. By the principle of Structure Preservation (Kiparsky 1982, 1985, also Aronoff 1976), restrictions on feature occurrence persist throughout the lexical phonology, and new segment types are only created in the post-lexical phonology. In the case of eclipsis, which is a morphologically-induced process (and thus lexical), new segment types should not be created. This is not the case, however. Eclipsis does expand the segmental inventory, as attested by examples which include the prenasalized stops in Hebridean Gaelic, the voiced stops (aspirated and unaspirated) in Applecross Gaelic, and the aspirated nasals in Welsh. On the other hand, eclipsis is subject to inventory constraints in some cases, as demonstrated by the failure to derive *z* in Irish and Gaelic or ŋ in Manya.

In Optimality Theory the principle of Structure Preservation can not be applied wholesale, since one of the basic tenets of OT is that the phonological inputs are not constrained. Any segment or combination of features is possible in the input, subject to universal constraints. In an Optimality Theoretic framework, the ability of a process such as eclipsis to violate inventory constraints is due to the ranking of output constraints, as is the inability of the same process to violate other inventory constraints. The otherwise forbidden segments that are derived by eclipsis come about through the action of MORPH REAL (which forces coalescence) and the interaction between faithfulness constraints.

The failure of Structure Preservation is typical in cases of coalescence. The succeeding subsections show how inventory constraints can be violated in coalescence, yielding non-structure-preserving effects. Section 3.4.1 looks at Sanskrit vowel coalescence, showing how mid vowels are derived through coalescence but otherwise ruled out. In the ternary scales model coalescence produces new segments under the influence of the relative faithfulness constraints IDENT [X] and IDENT-ADJ [X], which require that the coalesced output not get too far away from either input. Under standard binary features, however, the special status of coalescence can not be accounted for. Section 3.4.2 considers the creation of voiced stops and prenasalized stops in Gaelic eclipsis. Again, the relative faithfulness constraints are responsible for the violation of inventory constraints. Section 3.4.3 considers the creation of aspirated nasals in Welsh, where the ranking of MORPH REAL and STAY [spread] conspire to force the violation of inventory constraints which are otherwise respected in the language. While coalescence may sometimes violate inventory constraints, it will not do so if the inventory constraints are ranked above the constraints (such as MORPH REAL) which force the coalescence.

3.4.1 Sanskrit Vowel Coalescence

To illustrate coalescence within the ternary scales model I begin with a straightforward case from outside the realm of consonant mutation. In Sanskrit, *a* coalesces with *i* to form *ee*, and with *u* to form *oo*.

(62) Coalescence of Sanskrit Vowels (Gonda, 1966)

c**a**	+	**i**hi	→	c**ee**ha	'and here'
tv**aa**	+	**ii**ś vara	→	tv**ee**ś vara	'you, O Lord'
c**a**	+	**u**ktam	→	c**oo**ktam	'and said'
s**aa**	+	**u**vaaca	→	s**oo**vaaca	'she said'

The Sanskrit vowel coalescence produces mid vowels, both within and across morphemes. However, all of these mid vowels are long, preserving the length of both of the original vowels (up to a maximum of two moras). There are no short mid vowels in Sanskrit: uncoalesced mid vowels therefore do not occur. So mid vowels occur under coalescence and are prohibited otherwise.

Within Optimality Theory, the constraints are all on the output, or on the relationship between the output and the input. It is therefore impossible to rule out mid vowels in the input. They must be ruled out in the output when not coalesced, and permitted in the output when due to coalescence. In coalescence there are two inputs for a single output, so the output is subject to faithfulness constraints on both inputs. Neither input can be faithfully preserved, however, since the output can not be both high and low at the same time. The faithfulness constraints conflict, and the coalesced mid vowel is chosen as the best way of satisfying them.

How is a coalesced output permitted to violate inventory constraints that other outputs must obey? The solution lies in the identification of the features and the faithfulness constraints involved. Vowel height distinctions, like voicing and (consonantal) stricture distinctions, should be made on a ternary scale. The Vowel Height scale is given in (63).

(63) Vowel Height Scale
HIGH, MID, LOW

As with the other scales, the order of the scale is defined by the adjacency relation: MID is adjacent to HIGH and LOW, but HIGH and LOW are not adjacent to each other. MID is therefore intuitively the best compromise between HIGH and LOW. The Vowel Height versions of the relative faithfulness constraints, IDENT [VH] and IDENT-ADJ [VH] (and the ranking between them), reflect this fact.

When applied to coalescence, the relative faithfulness constraints sometimes produce non-structure-preserving effects. In the presence of two inputs, the output must not get too far from either one of them. If *a* + *i* yielded *aa*, it would violate IDENT-ADJ [VH] with respect to the *i*. If it yielded *ii*, it would violate IDENT-ADJ [VH] for the *a*. It must therefore compromise at *ee*, which violates the lower-ranked IDENT [VH], as well as *MID V. This is shown below in (64). The coalescence, I assume, is driven by the constraint NO-DIPH, by which diphthongs are prohibited (Rosenthall 1994). (NO-DIPH must dominate UNIFORMITY in order to force the coalescence. UNIFORMITY is left out for space reasons, as elsewhere in this chapter. MAX must be high ranking to keep one of the vowels from simply deleting, but I leave it out for space reasons.)

(64) Relative faithfulness constraints derive Sanskrit coalescence

/ a_1 i_2 /	IDENT-ADJ [VH]	NO-DIPH	*MID V	IDENT [VH]
$aa_{1,2}$	*!			
$ii_{1,2}$	*!			
a_1i_2		*!		
√ $ee_{1,2}$			*	**

The ranking of the relative faithfulness constraints with respect to *MID V in (64) yields the correct result for Sanskrit coalescence. Coalescing to either a low or high vowel (in the first two candidates) yields a IDENT-ADJ [VH] violation. IDENT-ADJ [VH] outranks *MID V, so becoming a mid vowel is preferable to getting too far away from either input. Avoiding the mid vowel by avoiding coalescence (as in the third candidate) is also prohibited, due to NO-DIPH. A mid vowel (the last candidate) incurs two violations of IDENT [VH]. These violations are acceptable, however, since IDENT [VH] universally ranks lower than IDENT-ADJ [VH], and in Sanskrit also ranks below NO-DIPH.

In the uncoalesced case the relative faithfulness constraints give the correct result of disallowing mid vowels. In the case of an input *e*, it can simply become *a* (or *i*—other constraints will determine which one) while violating only the lower-ranked IDENT [VH]. This is shown in tableau (65).

(65) Relative faithfulness constraints derive lack of Mid Vowels

/ e_1 /	IDENT-ADJ [VH]	*Mid V	IDENT [VH]
√ a_1			*
√ i_1			*
e_1,		*!	

The key to inventory violation under coalescence is the presence of scalar faithfulness constraints working simultaneously on two inputs. IDENT-ADJ [VH] demands that the output not get too far from either input. Two violations of IDENT [VH] (incurred by 'averaging' coalescence) are better than one violation of IDENT-ADJ [VH]. The optimization of faithfulness to two inputs in such cases results in a value which neither input segment possesses, but which is in between the two input values. As in Sanskrit, the in-between value may even be ruled out in non-coalescence cases.

The same result can not be achieved using binary features. Within a binary features model we are led to the conclusion that faithfulness to [–high] and [–low] is high ranking in Sanskrit, outranking the markedness constraint that disallows mid vowels.[33] This is shown in tableau (66). I consider only different possible outcomes of the coalescence, assuming the effects of NO-DIPH (and MAX).

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[33] As formulated by McCarthy & Prince (1995), the IDENT constraints don't take + and – values, but other work (e.g. Pater 1995) shows that the addition of a feature (or switch from – to +) is not ranked the same as the loss of a feature (or switch from + to –). To make this distinction I have simply given the IDENT constraints + and – values here. The point is that the [–high] of the /a/ is preserved over the [+high] of the /i/, so that IDENT [–high] would have to outrank IDENT [+high] (and similarly for [low]). Since IDENT [+high] is dominated and plays no decisive role in selecting the output, I have left it (and IDENT [+low]) out of tableau (66).

(66) Sanskrit vowel coalescence in binary features

/ $a_1 + i_2$ /	IDENT [–high]	IDENT [–low]	*MID V
a. $aa_{1,2}$		*!	
b. $ii_{1,2}$	*!		
c. √ $ee_{1,2}$			*

By tableau (66) the low and high vowels (candidates (a) and (b)) are rejected because they do not maintain the [–high] and [–low] specifications of /a/ and /i/ respectively. So candidate (c) wins, although it violates the markedness constraint against mid vowels.

The ranking in (66) must be false, however. By the ranking in (66) an input /e/ or /o/ would also surface, contrary to the facts of the language, which disallows short mid vowels. This is shown in (67).

(67) Ranking in (66) leads to uncoalesced mid vowels

/ e_1 /	IDENT [–high]	IDENT [–low]	*MID V
a. a_1		*!	
b. i_1	*!		
c. ♦ e_1			*

Just as in tableau (66), [+high] or [+low] may not be added, since doing so would violate IDENT [–high] or IDENT [–low]. The mid vowel surfaces unscathed. The ranking in tableaux (66) and (67) is therefore incorrect. An input *e* or *o* in Sanskrit must not be permitted to surface. The lack of output *e* and *o* leads to the conclusion that *MID V must be ranked above IDENT [–high] and/or IDENT [–low]. Tableau (68) illustrates such a ranking.

(68) Ruling out Sanskrit mid vowels in binary features

/ e_1 /	IDENT [–high]	*MID V	IDENT [–low]
a. √ a_1			*
b. i_1	*!		
c. e_1		*!	

By tableau (68) a mid vowel becomes a low vowel to avoid violating the *MID V constraint. The ranking of *MID V above IDENT [–low] (or above IDENT[–high]) means that a mid vowel can be avoided. The faithfulness constraint violated by ceasing to be mid is a less serious violation that surfacing as mid.

The ranking in tableau (68) is also wrong. If the ranking of tableau (68) is applied to the tableau in (66), then *aa* is falsely predicted as the outcome of the coalescence of /a/ and /i/, since it is better to violate IDENT [–low] than to be mid. We have, therefore, a paradox: coalescence creates segments such as mid vowels in attempting to be faithful to two inputs, while faithfulness to a single input is too low-ranked to preserve marked feature values. A single constraint ranking using faithfulness constraints on binary features can not describe both the coalesced and the uncoalesced outcomes.

By contrast the ternary scales model, using the relative faithfulness constraints, correctly captures the effect of non-structure preserving coalescence. The ternary analysis of Sanskrit coalescence emphasizes that IDENT-ADJ [X] and IDENT [X] are separate constraints. A single violation of IDENT-ADJ [X] is not equivalent to two violations of IDENT [X]. They are two categorical constraints that are ranked with respect to each other and allow other constraints to be ranked between them. The constraints are categorical because the adjacency relation is categorical: values either are or are not adjacent (and similarly are or are not identical). The adjacency relation, while itself binary, describes a scale which is not binary. The use of ternary scales and the relative faithfulness constraints that act on them provides an analysis of averaging coalescence that escapes the paradox of a binary features analysis.

The present application is to consonant mutations, as pursued in the following sections. The relative faithfulness constraints have been shown in the previous sections to be at work in deriving the output of eclipsis coalescence. Like Sanskrit vowel coalescence, eclipsis coalescence is not always structure preserving, due to the effects of IDENT [IV] and IDENT-ADJ [IV]. Some extra work is done in some cases by the MORPH REAL constraint, but otherwise the analyses are very similar to Sanskrit.

3.4.2 Gaelic Eclipsis Coalescence

In Applecross Gaelic eclipsis of voiceless stops creates voiced stops. In the more conservative variety the aspiration is retained if the voiceless stop is aspirated. Voiced stops (aspirated or unaspirated) are not otherwise permitted in Applecross Gaelic (Ternes 1973). A voiceless stop (IV1) coalescing with a sonorant (IV3) creates a voiced stop (IV2). This situation is exactly parallel to the case of Sanskrit vowel coalescence, but the scale on which the averaging coalescence occurs is the Inherent Voicing scale, not the Vowel Height scale. In becoming voiced, the output is adjacent to both inputs, violating IDENT [IV] twice, and IDENT-ADJ [IV] not at all. The coalescence is driven by MORPH REAL, which is left out of the tableau in (69), since only coalesced candidates are considered.

(69) Coalescence derives voiced stops

/ M_1 t_2 /	IDENT-ADJ [IV]	*IV2	IDENT [IV]
$t_{1,2}$	*!		
$n_{1,2}$	*!		
√ $d_{1,2}$		*	**

By the ranking of IDENT-ADJ [IV] above *IV2 and IDENT [IV], the first two candidates in (69) are ruled out, since they are too far away from one or the other of the input candidates.

The fate of an underlying voiced stop is different, however. Since *IV2 outranks IDENT [IV], an output will avoid being voiced if it can do so by only violating IDENT [IV]. An underlying /d/ could then surface as either *t* or *n* (depending on other constraints). This is shown in (70).

(70) Underived voiced stops ruled out

/ d_1 /	IDENT-NON-ADJ	*IV2	IDENT-ADJ
√ t_1			*
√ n_1			*
$d_{1,}$		*!	

As tableau (70) demonstrates, an underlying (therefore uncoalesced) voiced obstruent can not surface, since *IV2 outranks IDENT [IV]. An underlying voiced obstruent can avoid surfacing by violating only IDENT [IV]. The same ranking yields voiced obstruents in the coalesced eclipsis case in (69) and forbids voiced obstruents in the uncoalesced case in (70).

In the conservative variety of Applecross Gaelic the aspiration is retained when an aspirated voiceless stop undergoes eclipsis. This leads to the creation of aspirated voiced stops, which are even more marked than the plain voiced stops created in tableau (69). The ranking that causes the voiced aspirates is one in which STAY [spread glottis] dominates the *VOICED ASPIRATE constraint. This ranking ensures that aspiration will not be lost when the stop voices. That the stop will be voiced is determined already by the ranking in (69). The retention of aspiration is shown in (71).

(71) Creation of voiced aspirates in Applecross Gaelic

M + t^h	IDENT-ADJ [IV]	STAY [spread]	*VOICED ASP	IDENT [IV]
t^h	*!			
d		*!		**
√ d^h			*	**

As tableau (71) shows, the eclipsis output must be adjacent to both inputs, and yet retain the aspiration of the input voiceless stop. This means that a voiced aspirate is created, despite the constraint forbidding them. An input /d^h/ would have a different fate, however. It could retain its aspiration, but avoid a *VOICED ASP violation by becoming t^h. Such a move violates only IDENT [IV], as shown in tableau (72).

(72) Underived voiced aspirates fail to surface

d^h	IDENT-ADJ [IV]	STAY [spread]	*VOICED ASP	IDENT [IV]
√ t^h				*
d		*!		
n		*!		*
d^h			*!	

By the ranking in tableaux (71) and (72), voiced aspirates are created through coalescence of an aspirated voiced stop and a sonorant. Underlying voiced aspirates do not surface, though, because they can simply devoice and obey the *VOICED ASP constraint by violating only IDENT [IV]. In the progressive variety of Applecross Gaelic, the aspiration is not retained when an aspirated voiceless stop undergoes eclipsis. This is due to a reversal of ranking between STAY [spread glottis] and *VOICED ASP. If *VOICED ASP is ranked above STAY [spread glottis], then the aspiration will be lost when the segment voices. By inspecting tableau (71) is can be seen that reversing the *VOICED ASP and STAY [spread glottis] constraints leads to the selection of *d* as the optimal output for M + t^h. In tableau (72) it can be seen that switching these two constraints does not alter the outcome in the uncoalesced case. An input /d^h/ will still devoice to t^h.

The creation of otherwise-banned voiced stops and the retention of aspiration are well demonstrated by the Applecross Gaelic case. In the Hebridean dialects of Gaelic, however, the voiceless stops don't just voice, they also prenasalize. Prenasalization, which preserves the IV3 value of the M morpheme, incurs fewer IDENT [IV] violations that straightforward voicing, although prenasalized stops are otherwise ruled out in the language. Prenasalization as a way of minimizing IDENT [IV] violations was the analysis pursued in 3.3.2 above. The fact that prenasalized stops are not otherwise allowed to surface derives from the *PRENASAL constraint. An input prenasalized stop could simply become a plain nasal without violating IDENT [IV], since it already possesses the IV3 value (it would of course violate STAY 2, dominated anyway since input plain voiced obstruents do not remain—see tableau (70)). The prenasalized stop is preferred as the result of eclipsis, however, since a plain nasal would violate IDENT-ADJ [IV] and a plain voiced obstruent would incur an extra IDENT [IV] violation.

The preceding remarks on prenasalization hold at least for the dialects of the South Hebrides. The case in Skye and Lewis may be somewhat different. In Skye and Lewis the epenthetic eclipsis segment (which should be able to faithfully preserve the M's features) surfaces as ^{N}d (Borgstrøm 1941).[34] Why

[34] Borgstrøm reports that in Lewis the stop part of the eclipsis outputs is sometimes missing. In

should the eclipsis morpheme show up as a marked prenasalized stop if there is nothing keeping it from being a full IV3 nasal? One possibility is that the eclipsis morpheme has become reanalyzed. Given that the result of eclipsis in non-epenthetic environments is always a prenasalized stop, it would be simple to reanalyze the eclipsis morpheme as containing [nasal] and IV2-3, not just IV3. Thus the eclipsis morpheme in Skye and Lewis may actually be a prenasalized segment, while the eclipsis morpheme in the South Hebrides is a plain sonorant nasal. In order to realize the prenasalized segment, the faithfulness constraints on it (i.e. STAY 2 and STAY 3) must outrank the markedness constraint *PRENASAL. The problem with this solution is that prenasalized stops should then become available in the language as a whole, where they do not, in fact, appear. Since the faithfulness constraints on prenasalized stops would have to higher ranked than the markedness constraint which prohibits them, prenasalized stops could surface anywhere.

A second possibility is adapted from Ní Chiosáin's (1991) analysis of vowel-initial stems in Irish. Ní Chiosáin presents evidence that vowel-initial stems in Irish actually begin with an underspecified consonant. If this is so, then the eclipsis in the epenthetic case actually involves a coalescence of two underspecified segments (the stem-initial consonant and the mutation segment). Applying this to Gaelic, it could be said that in Skye and Lewis the underspecified initial consonant is specified for IV1. Then coalescence with the IV3 of the M segment would yield a prenasalized stop as usual. Prenasalized stops in other environments can then be ruled out as in the other Hebridean dialects, described above.

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other words, sometimes the eclipsis outputs are pure nasals, and the epenthetic output is also a nasal. In such cases the speakers are presumably promoting the markedness constraints against prenasalized stops, and the outcome is as in Welsh, described in 3.3.4

3.4.3 Welsh Eclipsis Coalescence

In Welsh the eclipsis mutation derives aspirated nasals as the output of M plus aspirated voiceless stops, as discussed in section 3.3.4. Aspirated nasals do not otherwise occur in Welsh. As was shown in tableau (51b) (repeated here as (73)), the coalescence of M with a voiceless stop gives a nasal in Welsh because *IV2 is ranked above IDENT-ADJ [IV]. Under the force of MORPH REAL, the coalescence must show some effect from the M, but an IV2 output (which would only violate IDENT [IV]) is out due to the *IV2. IDENT-ADJ [IV] must be violated instead. The aspiration is preserved due to the high-ranking of STAY [spread glottis], with the result that the mutation creates aspirated nasals.

(73) Creation of aspirated nasals in Welsh

M + t^h	MORPH REAL	*IV2	STAY [spread]	IDENT-ADJ [IV]	IDENT [IV]
$t^h_{1,2}$	*!			*	
$d_{1,2}$		*!	*		*
$d^h_{1,2}$		*!			*
$n_{1,2}$			*!	*	
√ $n^h_{1,2}$				*	

The ranking in (73) is also consistent with the fact that nasal aspirates do not occur in Welsh in non-eclipsis environments. The constraint against nasal aspirates, *NASAL ASP must be highly ranked, so as to do away with underlying nasal aspirates. It must be ranked below MORPH REAL and *IV2, however, to allow the nasal aspirates to be created under eclipsis and to be favored over an IV2 segment. Inspection of tableau (73) shows that the introduction of the *NASAL ASP constraint between STAY [spread] and IDENT-ADJ [IV] does not change the outcome of the mutation. This ranking of *NASAL ASP accounts for the fact that underlying aspirated nasals may not surface. Because *NASAL ASP ranks below STAY [spread], the stem segment's aspiration was retained under eclipsis. Similarly, an underlying nasal aspirate will retain its aspiration. The ranking of *NASAL ASP over IDENT-ADJ [IV] means that a segment can change its IV value to any required extent to satisfy *NASAL ASP. As shown in tableau (74), an input nasal aspirate will not surface as such, becoming an voiceless aspirate instead.

(74) Underlying nasal aspirate becomes voiceless obstruent

/ n^h /	*IV2	STAY [spread]	*NASAL ASP	IDENT-ADJ [IV]	IDENT [IV]
$n^h_{1,2}$			*!		
$n_{1,2}$		*!			
$d^h_{1,2}$	*!				*
$d_{1,2}$	*!	*			*
√ $t^h_{1,2}$				*	

As tableau (74) shows, attempts to satisfy *NASAL ASP by deaspiration or by moving to IV2 fail. An input nasal aspirate moves all the way to IV1, retaining its aspiration, but violating IDENT-ADJ [IV].

The Welsh case shows that not all non-structure-preserving coalescence is the averaging type, where coalescence of value 1 and value 3 on a scale leads to value 2. In this case the average value is ruled out because the constraint forbidding it outranks IDENT-ADJ [IV]. The structure preserving IV1 value is ruled out because of the nature of MORPH REAL, which demands that the M morpheme have a surface effect. The non-structure-preserving segment is forced to surface because it is the only way to satisfy MORPH REAL. Tautomorphemically this type of non-structure-preserving coalescence could not occur. This is unlike averaging coalescence, which can occur anywhere (as in Sanskrit) where coalescence can occur. The fact that averaging coalescence does not occur in non-mutation environments in cases like Applecross Gaelic implies only that coalescence of consonants is not permitted in other environments (as it is ruled out by UNIFORMITY), and that only MORPH REAL triggers coalescence it that language.

This section has shown a variety of non-structure-preserving effects in coalescence. In the case of averaging coalescence, such as Sanskrit vowel coalescence or Gaelic eclipsis, the inventory constraints are violated under pressure from the relative faithfulness constraints. The output must not get too far from either input: it may violate IDENT [IV], but not IDENT-ADJ [IV], so it will fall between the two input values on the scale. An underlying segment that holds that middle value (e.g. mid vowel or voiced obstruent) will be able to move away from it by violating only IDENT [IV].

Other cases of inventory violation come from the effects of MORPH REAL. In Welsh, for instance, the middle value (IV2) is ruled out by a very high ranking constraint. Yet MORPH REAL must be satisfied. Together with the high ranking of STAY [spread glottis] this leads to the creation of aspirated nasals. Other, unmutated aspirated nasals can be ruled out, however, since they can become voiceless aspirates without involving MORPH REAL. In Welsh it is significant that the coalescence is specifically a mutation coalescence, with MORPH REAL demanding an effect from the mutation. In the averaging cases, of Gaelic voicing and prenasalization, and of Sanskrit vowel coalescence, the shape of the coalescence is derived solely from the relative faithfulness constraints.

In each of the languages discussed in this section there is some failure of structure preservation under eclipsis coalescence. However, in each language (except Manya) discussed in this chapter, there are some segments that resist eclipsis due to inventory constraints. In Irish and Gaelic, for example, *s* does not undergo eclipsis. The constraint against the 'average' value, i.e. the voiced fricative *z*, is higher ranked than the MORPH REAL constraint, which would cause coalescence. This was shown in tableau (21) in Section 3.3.1. It is therefore not true that Structure Preservation is a condition that is either 'off' or 'on' during consonant mutation. Rather, Structure Preservation will hold if the inventory constraints are ranked above MORPH REAL, and it will fail if the inventory constraints are ranked below MORPH REAL. Thus eclipsis in a single language may be partly structure preserving and partly not, depending on the markedness constraints against particular types of segments.

3.5 Conclusions

This chapter has placed within a coherent framework nasalizing chain shifts in both assimilation and consonant mutation. The chain shifting form results from the relative faithfulness constraints IDENT [X] and IDENT-ADJ [X] when these constraints dominate the specific faithfulness constraints of Chapter 2. The relative faithfulness constraints, and the universal ranking between them, capture the fact that a move to an adjacent value on the scale is preferred to a long move to a value not adjacent on the scale. Applied to assimilation, this accounts for cases where voiceless obstruents voice while voiced obstruents fully assimilate to a nasal: in both cases, the assimilation (or attraction) output violates IDENT [IV], but not IDENT-ADJ [IV].

Nasalizing mutations are analyzed in this chapter as coalescence of an underspecified sonorant segment with a stem-initial consonant, under pressure from MORPH REAL. The shape of the coalescence is determined by the relative faithfulness constraints, with some effects from inventory constraints and other faithfulness constraints. Due to the ranking of IDENT-ADJ [X] over IDENT [X], coalescence will generally have a chain-shift shape, so that the output is not too far from the input. This is the case in Irish, Gaelic and Manya. In Welsh, however, the unavailability of the adjacent IV2 value means that the voiceless stops must violate IDENT-ADJ [IV] in order to satisfy MORPH REAL. In Fula, on the other hand, the MORPH REAL constraint is low ranked, and the mutation can only proceed if it does not even violate IDENT [IV].

The application of the relative faithfulness constraints to mutation coalescence is a special case of their application to general coalescence. Coalescence of the ends of a scale will 'average out' to the middle value on the scale, so that IV2 is the result of coalescing IV1 and IV3, and MID is the result of coalescing LOW vowels and HIGH vowels. This is the natural effect of the relative faithfulness constraints: it is better to compromise at the mid value, violating IDENT [X] twice, than to go all the way to one end, violating IDENT-ADJ [X]. This explains why averaging coalescence can sometimes violate inventory constraints. If the middle scale value is forbidden by a markedness constraint (see Chapter 4), then an input middle value will be lost, violating only IDENT [X]. But in order for the coalescence to avoid the middle value it must violate the higher-ranked IDENT-ADJ [X]. The result is that coalescence often does choose the middle value in spite of the inventory constraint.

Both in this chapter and in Chapter 2 the concept of adjacency has been invoked to describe a state that is less satisfactory than identity, but better than non-adjacency. In Chapter 2 attraction to an adjacent scale value was seen as a second-best to full assimilation. The concept of adjacency can also be used to define a scale: the order of the scale can be said to be derived from the adjacency relations between the values. In other words, voiced obstruents are in the middle of the scale because they are in an adjacency relation with both voiceless obstruents and with sonorants, while sonorants are only adjacent to voiced obstruents, and voiceless obstruents are also only adjacent to voiced obstruents.

Using the adjacency relation a larger scale might be constructed if motivated by the data (say, for more than three vowel heights).

A broader interpretation of adjacency is available, although I will not pursue it here in depth. In the preceding sections I have referred to adjacency as being spatially defined, so that IDENT [X] is violated by a segment moving to a neighboring value, and IDENT-ADJ [X] is violated by a segment taking on a non-neighboring value. Another way of thinking of it lies in the difference between one and more than one. The difference between IDENT [X] and IDENT-ADJ [X] is that in violating only IDENT [X] the output differs from the input by one value on the scale, while in a violation of IDENT-ADJ [X] the output differs from the output by more than one on the scale. Similarly, in the area of assimilation, ADJACENT is satisfied by a difference of one value on the scale, while no assimilation constraints are satisfied by a difference of more than one value on the scale. It may be, then, that there is a basic difference between violating a constraint once and violating it more than once, which could have consequences in other areas of phonology. This idea is similar to Smolensky's (1995) Local Self Conjunction, which holds that if a constraint is violated twice within some local domain, the constraint violation is worse than two separated violations of the same constraint. The important difference between local self conjunction and adjacency is that adjacency recognizes only the difference between one and more than one, while local conjunction can potentially recur and so recognize the difference between one and two, two and three, etc. A testing ground for the difference between adjacency and local conjunction would be in a scale of more than three values, where a difference between two and three could potentially show up. The possibility of extra-ternary scales is returned to briefly in Section 5.4.4.

CHAPTER 4

MARKEDNESS AND NEUTRALIZATION ON THE INHERENT VOICING SCALE

Amahl: Sure enough, there are not two Kings outside.
Mother: That is surprising.
Amahl: The Kings are three…
Gian Carlo Menotti, *Amahl and the Night Visitors*

4.1 Introduction

The ternary IV scale represents three equal values of voicing, but these values are not equally represented in the world's languages. Non-contextually, at least, the IV2 value is the marked value of the scale (Jakobson & Halle 1956, Trubetzkoy 1969) and hence IV2 segments are less common cross-linguistically than are the voiceless IV1 segments (Maddieson 1984). The markedness of voicing in obstruents was part of the motivation for making [voice] a privative feature that is unspecified in sonorants, in works such as Lombardi (1991). The loss of markedness occurring in coda neutralization was represented as a loss of phonological structure through delinking of [voice] and other laryngeal features (Clements 1985, McCarthy 1988). So markedness was considered to be reflected in feature geometric structure: the more structure, the more marked the segment. For this reason voicing, which is present in both voiced obstruents and sonorants, was considered specified (and thus marked) in obstruents and unspecified (and so unmarked) in sonorants.

In the present framework, underspecification plays no role, since all segments have a value on the IV scale. Sonorants (IV3) need not be unspecified for voicing because their voicing value is different from that of voiced obstruents (IV2). Indeed, working without input underspecification is required by Optimality Theory, since in OT the constraints are only on the outputs and the inputs are unconstrained. In OT it is impossible to rule out a sonorant that is specified for [voice] at the input.

In the ternary scales model it is not the presence of a [voice] node that is marked, but rather the presence of the middle value on the scale. The reason for this is that it is the presence of the middle value that introduces ternarity into the phonology. Without the middle value, the scale is simply a maximally dispersed binary distinction, with voiceless obstruents at one end, and inherently voiced sonorants at the other. This takes Liljencrants & Lindblom's (1972, also Lindblom 1986) principle of maximal contrast and transfers it from the realm of vowels to other phonological dimensions. By the principle of maximal contrast maximally contrasting values are preferred, so that voiceless obstruents and sonorants are preferred on the IV scale, and voiced obstruents are marked. Leaving out a value on a ternary scale is a simplifying move. Taking out a value at either end of the scale (IV1 or IV3) leaves a binary distinction, but one that is not maximally dispersed. IV1 and IV2 or IV2 and IV3 are not as distinct as IV1 and IV3. IV2 is therefore the most marked value of the phonological scale, because leaving it out yields a system that makes a maximal contrast between remaining values.[1]

The non-contextual markedness of the IV2 value is referred to in the phonology by a markedness constraint *IV2 . This constraint exists in the absence of *IV1 and *IV3 constraints (or alternatively, can be said to always outrank *IV1 and *IV3). Any output segment that possesses the IV2 value will incur a violation of the *IV2 constraint. The violation of *IV2 will not be decisive if a segment is underlyingly IV2 and STAY 2 is ranked above *IV2 (or if some other constraint, such as an assimilation constraint or a contextual markedness

[1] Voiced obstruents are also *phonetically* marked, that is, it is difficult to maintain voicing in a closed oral tract. The difficult phonetic requirements are related to the difficult phonological requirement--that of being phonetically like (phonologically adjacent to) a sonorant (and thus voiced) and also like a voiceless obstruent (and thus preferring to be voiceless).

constraint demands the presence of the IV2). The violation of the *IV2 is crucial, however, if STAY 2 ranks below *IV2, or if a segment is epenthetic and STAY 2 is therefore inapplicable.

The present chapter presents a brief overview of the effects of markedness in the context of the ternary scales model, with applications to the IV scale. Section 4.2 deal with epenthesis, showing that in the presence of the *IV2 constraint epenthetic segments will be either IV1 or IV3. Section 4.3 introduces interactions with faithfulness constraints. If *IV2 outranks STAY 2, a language will not have voiced obstruents in its inventory. If the other ranking holds, the language will permit them. Section 4.4 discusses cases where IV2 segments are generally ruled out (by *IV2 dominating STAY 2), but IV2 segments still occur in certain cases through the effects of relative faithfulness constraints or of contextual markedness constraints. Section 4.5 looks at the specific case of coda neutralization, where IV2 is ruled out in codas. The fact that voiced obstruents become voiceless under these circumstances is due to the ranking of faithfulness constraints introduced in Chapter 2, whereby adding IV1 is more harmonic than adding IV3. Section 4.6 looks at cases where coda neutralization is overruled, that is, cases of coda assimilation. These cases demonstrate the interaction between the *IV2 constraint and the ASSIM constraint discussed in Chapter 2. If ASSIM outranks *IV2, assimilation of a voiceless obstruent to a voiced obstruent will take place, although neutralization may still take place finally. Section 4.7 concludes.

4.2 Epenthesis: Eastern Massachusetts English, Axininca Campa

In McCarthy & Prince's (1995) formulation of the Correspondence Theory of faithfulness (which I follow here), the introduction of an epenthetic segment is regulated by *segmental* faithfulness and *featural* markedness. In other words, while the faithfulness constraint DEP is violated by the introduction of an epenthetic segment, the RESIST constraints are inapplicable. An epenthetic IV3 segment does not violate RESIST 3, since it does not correspond to an input segment that lacks IV3. In epenthesis, therefore, the markedness constraints control which features an epenthetic segment will have.

Given the presence of the *IV2 constraint, and the corresponding absence (or low-ranking) of *IV3 and *IV1 constraints, it is evident that voiced obstruents will be avoided in epenthetic cases. Epenthetic segments are predicted to be either voiceless (IV1) or sonorant (IV3). Constraints such as those on sonority (which are generally low-ranked) will choose between IV1 and IV3.

I begin with a case of IV3 epenthesis. In the dialects of eastern Massachusetts, an 'intrusive' *r* occurs word-finally after ɑ, ə, or ɔ and before another vowel. The intrusive, epenthetic *r* is can be distinguished from the etymological final *r* that appears under much the same circumstances and deletes elsewhere (McCarthy 1991, 1993b). Examples of intrusive *r* are shown in (1) (from McCarthy 1993b).

(1) Epenthetic *r* in eastern Massachusetts
François*r* is coming
subpoena*r*ing
guffaw*r*ing
a Pollyanna*r*ish attitude
schwa*r* epenthesis

McCarthy (1993b) analyzes the intrusion of *r* to be the result of a constraint requiring words to end in a consonant: FINAL-C. It is dominated, however, by a coda condition prohibiting *r* in coda positions. It is only, therefore, when *r* is followed by a vowel (and can, by being ambisyllabic, both close its prosodic word and occupy the following onset) that it can be epenthesized to satisfy FINAL-C.

McCarthy's analysis assumes containment, the principle in Prince & Smolensky (1993) whereby epenthesis is phonologically the positing of empty prosodic structure and is spelled out only phonetically as the default segment. This leaves the choice of *r* as an epenthetic segment difficult to explain, since as McCarthy notes '*r* is demonstrably not the default consonant in English' (p.190). In the correspondence-based view of faithfulness adopted here (following McCarthy & Prince 1995) epenthetic consonants are fully spelled out in the output of the phonology, and their quality is determined by constraint interaction. Epenthesis is contextual, however, so a language may have different default segments depending on the phonological context. The point here is to determine that the 'intrusive' segment can not be IV2, and to further suggest why IV3 is chosen over IV1. The general markedness constraint *IV2 ensures that the epenthetic segment will not be IV2, as illustrated in the following tableau.

(2) No epenthesis of IV2 in Bostonian English

schwa epenthesis	FINAL-C	*IV2
schwa epenthesis	*!	
schwa**d** epenthesis		*!
√ schwa**r** epenthesis		

Only the epenthesizing candidates in (2) obey FINAL-C. Among the epenthesizing candidates, the one with an IV2 segment loses, due to the markedness of the middle value on the IV scale. The remaining question is why the IV3 *r* is chosen over an equally unmarked IV1 segment such as *t*. Given that other glides (*y* and *w*, after mid and high front and back vowels) appear in the same word-final but ambisyllabic position, it is not surprising that the pharyngealized glide *r* should accompany the pharyngealized low vowels.

Presumably coarticulation with the vowel is required in this environment, and so the IV3 *r* is the best epenthetic segment in these circumstances.

In other contexts the constraint ranking favors IV1. The Arawakan language Axininca Campa resolves non-initial hiatus with epenthesis of the IV1 segment *t* (Payne 1981; McCarthy & Prince 1993, 1994).[2] The epenthesis is illustrated in (3).

(3) Epenthesis of *t* in Axininca Campa

/i-N-koma-i/	iŋkoma*t*i	'he will paddle'
/i-N-koma-aa-i/	iŋkoma*t*aa*t*i	'he will paddle again'
/i-N-koma-ako-i/	iŋkoma*t*ako*t*i	'he will paddle for'
/i-N-koma-ako-aa-i-ro/	iŋkoma*t*ako*t*aa*t*iro	'he will paddle for it again'
/i-N-č^{h}iki/	iñč^{h}iki	'he will cut'
/i-N-č^{h}ik-aa-i/	iñč^{h}ikaa*t*i	'he will cut again'
/i-N-č^{h}ik-ako-i/	iñč^{h}ikako*t*i	'he will cut for'
/i-N-č^{h}ik-ako-aa-i-ro/	iñč^{h}ikako*t*aa*t*iro	'he will cut for it again'

In the examples in (3) a *t* is inserted to provide onsets to otherwise vowel-initial syllables (except word-initially). The presence of the epenthetic segment is required by the ONSET constraint (McCarthy & Prince 1993, 1994), but the quality of the epenthetic segment is left up to other constraints. Given the markedness constraint *IV2, we can predict that the epenthetic segment will not be a voiced obstruent. This is shown in tableau (4).

[2] French also has epenthesis of *t* in subject-verb inversion. I illustrate with the epenthesis of *t* rather than the more common epenthesis of ʔ, to avoid the question of whether ʔ is voiceless (IV1) or sonorant (IV3).

(4) IV2 not epenthetic in Axininca Campa

/i-N-koma-i/	ONSET	DEP	*IV2
iŋ.ko.ma.i	*!		
iŋ.ko.ma.**d**i		*	*
√ iŋ.ko.ma.**n**i		*	
√ iŋ.ko.ma.**t**i		*	

The first candidate, which does not have any epenthesis, is ruled out by ONSET. The second candidate does have epenthesis, but introduces a marked IV2 segment. The sonorant and the voiceless obstruent are therefore the winners of this tableau.

To decide between the IV1 epenthesis and the IV3 epenthesis, Axininca Campa calls on sonority constraints. Syllable onsets prefer to be of low sonority.[3] The *t* therefore makes a better onset than a sonorant such as *n* would. Gnanadesikan (1995a,b), building on Prince & Smolensky (1993), derives this preference of low sonority segments for onsets from the correlating preference of high sonority segments for moraic position. There is therefore a subhierarchy of constraints of the form X → μ, which means 'X must be moraic'.[4] The constraint LOW V → μ dominates the subhierarchy which moves down the sonority hierarchy to the lowest ranked VOICELESS STOP → μ, as in (5).

(5) Sonority hierarchy and the X → μ constraints

Sonority type	Examples	Constraint
low vowel	a	LOW V → μ
mid vowel	e, o	MID V → μ
high vowel/glide	i/y, u/w	HIGH V → μ
liquid	l, r	LIQUID → μ
nasal	n, m	NASAL → μ

[3] For the use of sonority in syllabification, see among others Jespersen 1904, Hankamer & Aissen 1974, Hooper 1976, Steriade 1982, Selkirk 1984, Dell & Elmedlaoui 1985, Zec 1988, Clements 1990, Prince & Smolensky 1993.

[4] The X → μ notation replaces the alignment notation of Gnanadesikan 1995a.

voiced fricative	z, v	IV2 FRIC → μ
voiceless fricative	s, f	IV1 FRIC → μ
voiced stop	b, d, g	IV2 STOP → μ
voiceless stop	p, t, k	IV1 STOP → μ

By the constraints in (5), *t* is a better non-moraic onset than any more sonorous segment. The preference for *t* over *n* is shown in tableau (6). Only the relevant parts of the subhierarchy of sonority constraints are shown.

(6) Sonority selects IV1 over IV3.

/i-N-koma-i/	NASAL →μ	IV1 STOP →μ
iŋ.ko.ma.ni	m n!	**k**
√ iŋ.ko.ma.ti	m	**k t**

In tableau (6) an epenthetic *n* gives the first candidate two high-sonority onsets, while the second candidate has two low-sonority onsets and only one high-sonority onset, so it wins.

The obvious question at this point is why *IV2 is needed at all. If the sonority constraints demand that low sonority segments be in onsets, then the *t* would be chosen over *d* in Axininca Campa anyway, since IV1 is the least sonorous IV value. In Eastern Massachusetts English, if a glide is independently wanted, then the *r* will independently be epenthesized, regardless of the presence or absence of a *IV2 constraint.

It is quite true that the epenthesis facts do not in themselves prove the existence of the *IV2 constraint. They do prove, however, that there can not be a higher-ranking *IV1 or *IV3 constraint. Assume, for the moment, that there are three non-contextual markedness constraints: *IV1, *IV2 and *IV3. Assume, furthermore, that they are freely rerankable (this is necessary, since assuming a fixed ranking of *IV2 above the others is indistinguishable from saying that the others don't exist, in the absence of a ranking between *IV1 and *IV3). In that case, it is quite possible that *IV1 could outrank *IV2 in a given language. If *IV1 also outranked the sonority conditions which prefer IV1 in onset (i.e. *IV1 >> IV2 STOP → μ), the language would choose IV2 as the IV value of the epenthetic segment. Tableau (7) illustrates such a hypothetical ranking in the hypothetical language of Axininca B.

(7) IV2 could be epenthetic in Axininca B

/i-N-koma-i/	*IV1	*IV2	IV2 STOP → μ	IV1STOP → μ
iŋkoma**t**i	k t!			**k t**
√ iŋkoma**d**i	k	**d**	**d**	**k**

In tableau (7) the IV1 epenthesis in the first candidate fails, because the hypothetical *IV1 is violated. Although the first candidate fares better on the sonority-related constraints, this is irrelevant. Because the *IV1 has eliminated the least sonorous IV1 segment, the case goes to the next-least sonorous IV2 candidate. (Introducing an IV3 candidate into the tableau would only help if *IV3 were ranked below *IV2 and *IV2 ranked above the IV3 → μ constraint.)

The tableau in (7) demonstrates that assuming freely rankable markedness constraints would predict the epenthesis of IV2 segments, regardless of sonority, in some cases. To my knowledge, such IV2 epenthesis does not occur.[5] Two possible conclusions can be drawn. The first is that there are no non-contextual markedness constraints operating on the IV scale (and ternary scales generally). The second is that there is a *IV2 constraint, and that this constraint exists in the absence of *IV1 and *IV3 constraints, or that it always outranks such constraints. The next section turns to further consequences of *IV2, showing that there is indeed such a constraint.

[5] See, however, the discussion in 3.4.2 of prenasalized voiced stops which result from mutation plus epenthesis in Skye and Lewis Gaelic. It is extremely doubtful that anyone would want to claim prenasalized stops as the unmarked default consonants, and this case does present other possible analyses, as pointed out in 3.4.2.

4.3 Inventory Restrictions: Pintupi

Another result of the *IV2 constraint is that voiced obstruents may be entirely lacking from a language's phonemic inventory. For example, of the languages in the UPSID data base (Maddieson 1984), 91.8% (291 languages) have plain voiceless stops, while only 66.9% (212 languages) have plain voiced stops. In languages that lack voiced obstruents the *IV2 constraint is highly enough ranked to disallow any output IV2 specifications, rather than just prohibiting epenthetic IV2 values. An example of a language without voiced obstruents is the Australian language Pintupi (Hansen & Hansen 1969).[6] The Pintupi phonemic inventory includes the IV1 segments *p, t, ṭ , tj*, and *k*; and the IV3 segments *m, n, ṇ , nj,* ŋ, *l, ḷ , lj, ř , w, y*, and *ṛ* ; but no IV2 segments.

The Pintupi-type inventory results from the ranking of *IV2 above STAY 2. If *IV2 outranks STAY 2, then an input IV2 segment will lose its IV2 specification in the output (at least, in the absence of higher ranking constraints such as those in the following section). The fate of an input IV2 segment is illustrated in the following tableau. STAY 2 is given the subscript 'all' to indicate that all applications of STAY 2 (whether general or specific to onsets or other prominent positions) are dominated by *IV2.

(8) Loss of input IV2 in Pintupi

/…d…/	*IV2	STAY 2_{all}
d	*!	
√ t		*

By tableau (8) an input IV2 segment fails to surface as such, since preserving the IV2 value would violate *IV2. Losing the IV2 value violates the lower ranked STAY 2. The tableau in (5) presents IV1 as the correct output for the input IV2.

[6] Welsh, discussed in Chapter 3, also conforms to this pattern.

That IV1 is the proper replacement for IV2 under such conditions of neutralization will be demonstrated in Section 4.5.

In other languages, such as English, IV2 specifications do manage to surface, despite the *IV2 constraint. English exhibits a full range of IV contrasts, as demonstrated by minimal sets such as *peek, beak, meek* or *tip, dip, nip*. In a language such as English the Pintupi ranking is reversed. STAY 2, which preserves IV2 values, must outrank the *IV2 that prohibits them. The ranking is illustrated in tableau (9).

(9) IV2 preserved in English

/…d…/	STAY 2	*IV2
√ d		*
t	*!	

The faithful IV2 candidate wins in English because it satisfies STAY 2, which is now ranked above *IV2.

The inclusion or exclusion of the marked IV2 value from a language's inventory springs simply from the interaction between the markedness constraint that forbids the value (here *IV2) and the faithfulness constraint that preserves it (here STAY 2), as laid out in Prince & Smolensky (1993: Ch 9). This is slightly more complicated that the epenthesis case in the previous section, where there are no effects from faithfulness. In the epenthesis case faithfulness to an underlying value is irrelevant. The IV2 value is therefore ruled out in epenthetic cases even when IV2 segments are otherwise allowed in the language. In the present section, the *IV2 constraint interacts with the faithfulness constraint STAY 2. In the following section the interactions become more complex.

4.4 Overriding Inventories: Relative Faithfulness and Contextual Markedness

While the *IV2 constraint may prohibit the inclusion of all IV2 segments from the phonological outputs of a language, it is also possible that *IV2 may be overruled by other constraints that require output IV2 segments in only certain contexts. These other constraints may include relative faithfulness constraints and contextual markedness.

Applecross Gaelic, discussed in more detail in 3.4.2 provides a good example of the domination of *IV2 by relative faithfulness constraints. In Applecross Gaelic, voiced obstruents do not generally occur. We can conclude, therefore, that an underlying IV2 segment will be weeded out by the *IV2 constraint, and that *IV2 dominates STAY 2. The situation is as in tableau (8) above. When a stem-initial segment undergoes mutation coalescence, however, IV2 segments are created as the coalescence of an IV1 segment with the IV3 mutation morpheme. As laid out in 3.4.2, the inventory constraint *IV2 is violated in this case because the relative faithfulness constraint *NON-ADJACENT does not allow the coalesced output to be too far from either of the two inputs. The tableau in (10) repeats tableau (69) of Chapter 3.

(10) IDENT-ADJ [IV] forces violation of *IV2

$M_1 + t_2$	IDENT-ADJ [IV]	*IV2	IDENT [IV]
$t_{1,2}$	*!		
$n_{1,2}$	*!		
√ $d_{1,2}$		*	**

The coalesced outputs in tableau (10) have two inputs to be faithful to. A value on either end of the IV scale would be too far from one input or the other. Only the 'averaged' IV2 value escapes IDENT-ADJ [IV]. Because of the force of the higher-ranked IDENT-ADJ [IV], *IV2 is rendered powerless in this case.

Markedness-defying IV2 segments therefore occur in such a mutation context. In the non-mutation context, it is IDENT-ADJ [IV] that is irrelevant, since an input IV2 segment can not violate IDENT-ADJ [IV] in escaping the marked IV2 value. An input IV2 segment can become IV1 or IV3 simply by violating the lower-ranked IDENT [IV].

Another way *IV2 may be violated in a language that otherwise respects it is in contexts where highly-ranked contextual markedness constraints are relevant. While IV2 is the most marked value non-contextually, other values are more marked in particular contexts. Take, for instance, the Australian language Gugu-Yalanji (Oates & Oates 1964). The Gugu-Yalanji consonant phonemes are *p*, *t*, *tj*, *k* (IV1) and *m*, *n*, *ñ*, ŋ, *l*, *r*, *rr*, *w* and *y* (IV3). The stop phonemes are generally voiceless. This means that *IV2 dominates STAY 2_{all}, as in Pintupi in 4.3 above. After nasals, however, the stops are voiced. Examples of the distribution are given in (11).

(11) Post-nasal voicing in Gugu-Yalanji[7]

pa**t**a	'lower down'	yirm**b**al	'mineral water'
ki**tj**a	'moon'	ŋaŋ**g**in	'porcupine'
tirra	'teeth'	pun**d**ay	'sit'
tji**p**arr	'south'	ŋan**j**ay	'smelling'

The voicing of the IV1 segments after a nasal can be attributed to Pater's (1995) *NC̥ , which is a contextual markedness constraint that rules out voiceless consonants (IV1) after nasals.[8] For typographic ease and notational consistency I will call the constraint *N+IV1 here. The *N+IV1 constraint must dominate the

[7] The examples in the text are from Oates & Oates (1964). However, Oates & Oates use an orthography in which all stops are represented as voiced. I have therefore altered the examples to reflect the distribution which Oates & Oates themselves report (p 2).

[8] Alternatively, this could be a case of attraction of the IV1 consonant toward the IV3 nasal. Another analysis of post-nasal voicing is Itô, Mester & Padgett (1993) who treat post-nasal voicing as the licensing of the [voice] feature in the nasal. In the present theory, [voice] is not a feature that sonorants can have.

*IV2 constraint in order to bring about the voicing in the post nasal environment. The full ranking responsible for the Gugu-Yalanji situation is given in (12).

(12) Ranking for Gugu-Yalanji voicing

a. *N+IV1>> *IV2 >> STAY 2
b. *N+IV1 >> RESIST 2
c. RESIST 3 >> *IV2

In (a), *N+IV1 dominates *IV2. This way the force of *IV2 is overridden when *N+IV1 applies. *IV2 dominates STAY 2, so that voiced obstruents are otherwise forbidden. In (b) *N+IV1 dominates RESIST 2. This is necessary in order to create the IV2 segments. In (c) RESIST 3 dominates *IV2. This is because the obstruents voice after nasals, violating *IV2, but do not become sonorants (which would satisfy *IV2, but violate RESIST 3).[9] The tableau in (13) illustrates the rankings in (12). The ranking of *IV2 over STAY 2 is left out for reasons of space and because it has already been illustrated in (8) above.

(13) Derivation of IV2 postnasally in Gugu-Yalanji

/yirmpal/	*N+IV1	RESIST 3	RESIST 2	*IV2
yirm**p**al	*!			
yirm**m**al		*!		
√ yirm**b**al			*	*

As the tableau in (13) shows, *IV2 has been rendered powerless postnasally because of the dominating *N+IV1(and RESIST 3). In general, the derivation of a voiced obstruent is permitted when a dominating constraint demands it. In Applecross Gaelic the dominating constraints are MORPH REAL (demanding that mutation occur) and *NON-ADJACENT, which keeps the output close to both

[9] A fully assimilated nasal may also be ruled out due to a constraint against geminates or sequences of nasals.

inputs. In Gugu-Yalanji, the dominating constraint is a contextual markedness constraint, *N+IV1.

4.5 Neutralization: Markedness in Codas

Syllable codas (or, in some cases, simply segments that are not pre-sonorant—see Lombardi 1991) are subject to certain markedness conditions that syllable onsets appear not to notice. While in some cases voiced obstruents are ruled out throughout a language (as in 4.3), in other cases the voiced obstruents are only missing in syllable codas. The additional sensitivity to markedness in codas may be accounted for in one of two ways. One approach is that of positional faithfulness (Beckman 1995, 1996; also Selkirk 1994). According to positional faithfulness, prominent syllable positions have extra faithfulness constraints, so that onsets receive higher faithfulness than syllable codas. Hence STAY 2 for onsets may be said to outrank the general STAY 2. The general STAY 2 might rank below *IV2 even though STAY 2-onset ranked above *IV2.

Another way, following Itô (1986), makes conditions on codas which onsets do not share. If one adopted this type of condition into the present framework, one could say that a constraint *IV2–CODA exists in addition to the general *IV2. Since *IV2 is violated whenever the more specific *IV2–CODA is (but not vice-versa), then *IV2–CODA will only be visible when it ranks above *IV2. If STAY 2 outranks *IV2 (allowing voiced obstruents in the language as a whole), it might still not outrank *IV2–CODA, which would mean that voiced obstruents would not be allowed in codas.

While acknowledging the two possibilities mentioned above for deriving the extra sensitivity of codas to the markedness of IV2, I pursue here the former approach, namely that of positional faithfulness. By this approach there is an additional constraint STAY 2-onset which outranks the general STAY 2.

The difference between STAY 2-onset and the general STAY 2 is well illustrated in a language such as German, which exhibits classic neutralization of coda obstruents. The neutralization is shown in (14) (data from Rubach, 1990). The relevant syllable boundaries are shown with a period in the phonetic transcriptions, so that [k.] means that the *k* is in a coda, while [.g] shows that the *g* is in an onset.

(14) German coda neutralization

Ta**g** [k.] 'day'	Ta**g**e [.g] 'days'
Kin**d** [t.] 'child'	kin**d**isch [.d] 'childish'
Hau**s** [s.] 'house'	Häu**s**er [.z] 'houses
Häu**s**chen [s.] 'house, dimin.'	
Smara**gd** [kt.] 'emerald'	Smara**gd**e [k.d] 'emeralds'
Ja**gd** [kt.] 'hunting'	Ja**gd**en [k.d] 'hunting, pl'
	ja**g**en [.g] 'to hunt'

As (14) shows, an underlying voiced obstruent will surface as voiced in onset position, but will undergo neutralization and surface as voiceless in a coda. Only voiced obstruents (IV2) are affected. Sonorants (IV3) are not affected, as shown in (15).

(15) Resistance of sonorants to neutralization

atme**n** [n.] 'to breathe'
Hande**l** [l.] 'trade'
Ordnu**ng** [ŋ.] 'order'

In coda neutralization such as the present German example, voiceless obstruents (IV1) and sonorants (IV3) are permitted in codas, but voiced obstruents (IV2) are not. The voiced obstruents devoice to IV1. Such neutralization will occur when *IV2 outranks STAY 2, but is in turn outranked by STAY 2-onset. The ordering requirement is shown in (16).

(16) Ranking deriving coda neutralization
STAY 2-onset >> *IV2 >> STAY 2

The ranking in (16) is illustrated in tableau (17).

(17) Coda Neutralization in German

a. IV2 disallowed in codas

/tag/	STAY 2-onset	*IV2	STAY 2
ta**g.**		*!	
√ ta**k.**			*

b. IV2 permitted in onset

/ta**g** + ə/	STAY 2-onset	*IV2	STAY 2
√ ta**.gə**		*	
ta**.kə**	*!		*

In tableau (17a) the ranking of *IV2 above STAY 2 means that an underlyingly IV2 segment can not surface as such in a coda. The devoiced candidate therefore wins. The ranking of STAY 2-onset over *IV2 allows IV2 values to surface in onsets, as shown in (17b) where the devoiced candidate earns a fatal STAY 2-onset violation.

Not shown in tableau (17a) is why the devoiced candidate is chosen over an IV3 candidate. The force of *IV2 is that voiced obstruents (IV2) are marked, but it says nothing about what value a segment will take on if it is driven from its underlying IV2 value. The status of IV1 as the result of neutralization is a result of the specific faithfulness constraints introduced in Chapter 2. In leaving the IV2 value a segment violates STAY 2, but it must also violate a RESIST constraint in order to surface with an IV value at all. Because of the fixed ranking of RESIST 3 >> RESIST 2 >> RESIST 1, a violation of RESIST 1 is always better (modulo higher, conflicting constraints) than a violation of RESIST 3. In seeking to obey the *IV2 constraint a segment will therefore devoice rather than become sonorant. The direction of the neutralization is not to be found in the neutralization-driving constraint itself, but rather in an independent set of faithfulness constraints. The effects of the RESIST hierarchy on neutralization are shown in tableau (18).

(18) IV1 as result of Neutralization

/ta**g**/	*IV2	RESIST 3	STAY 2	RESIST 1
ta**g.**	*!			
taŋ**.**		*!	*	
√ ta**k.**			*	*

By tableau (18), IV2 is forbidden in coda position, as in tableau (17). The contest is therefore between the second and third candidates. The second candidate violates the high-ranked RESIST 3 and the third candidate violates only the low-ranked RESIST 1. Devoicing is therefore the best way to avoid a coda voiced obstruent. Devoicing need not be represented by the loss of a [voice] node, as in privative approaches. Rather, the devoicing is a consequence of the ranking of the faithfulness constraints.

Of course not all languages that allow IV2 values in onsets neutralize them in codas. In English, for example, IV values are preserved in codas as well as onsets, as attested by sets such as *tack, tag, tang*; *pat, pad, pan*; or *rip, rib, rim*. In English, therefore, the general STAY 2 must rank above *IV2, as in tableau (9) above.

In summary, the *IV2 constraint is ranked so as to eliminate voiced obstruents from codas in German. The relevant ranking is such that the markedness constraint *IV2 outranks the general faithfulness constraint STAY 2, but not the more specific STAY 2-onset. The reverse ranking, STAY 2 >> *IV2, illustrated in a language such as English, faithfully preserves the marked IV2 values in codas as well as elsewhere.

4.6 Overriding Neutralization: Interaction with Assimilation

While some languages display the straightforward neutralization of German, discussed in the previous section, other languages have more complex neutralization facts because the *IV2 constraint interacts with the ASSIM constraint introduced in Chapter 2. In German ASSIM is obviously low-ranked, since coda assimilation does not occur. Specifically, it must rank below *IV2 since *IV2 rules out coda IV2 even when ASSIM would otherwise call for the coda consonant to be IV2. If ASSIM is more highly ranked,*IV2 can be overruled in some environments while remaining active in others.

Such assimilation-sensitive neutralization occurs in Dutch.[10] In Dutch neutralization occurs only when assimilation is inapplicable, as illustrated in (20) (data partially from van der Hulst 1980, 1985).

(20) Dutch assimilation and neutralization

hui**z**en	[.z]	'houses'
hui**s**	[s#]	'house'
hui**s**baas	[z.b]	'landlord'
hui**s**nummer	[s.n]	'house number'
za**kk**en	[.k]	'pockets'
za**k**	[k#]	'pocket'
za**k**doek	[g.d]	'handkerchief'
za**k**mes	[k.m]	'pocket knife'
bra**d**en	[.d]	'to roast'
braa**d**pan	[t.p]	'roasting pan'

As the above data show, an underlyingly voiced obstruent will devoice word finally (as in *hui***s** /z/, [s] 'house') and in a coda before a sonorant onset (*hui***s***nummer* 'house number'), but will retain voicing before a voiced obstruent (as in *hui***s***baas* [z] 'landlord'). An underlyingly voiceless obstruent will also voice before a voiced obstruent, as in *za***k***doek* [g] 'handkerchief'. Before a voiceless

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[10] Similar patterns of neutralization with assimilation occur in Catalan (Mascaró 1987) and in Polish (Rubach & Booij 1990).

obstruent, a voiced obstruent will be voiceless (as in *braa**d**pan* [t] 'roasting pan'), although this devoicing could result from either assimilation or neutralization.[11]

Simply put, assimilation occurs when it can, and neutralization occurs elsewhere. Elsewhere includes word-finally, where the environment for assimilation is not met, and also in a coda before a sonorant onset. Due to the high ranking of RESIST 3 (and low ranking of ADJACENT) obstruents may not assimilate to (or be attracted toward) sonorants in Dutch (which is therefore like Hungarian and Sudanese Arabic of Chapter 2). Neutralization therefore only occurs where assimilation is inapplicable (word-finally) or independently ruled out (before sonorants).

Like German, Dutch must rank *IV2 above the general STAY 2 to require neutralization, while ranking it below STAY 2-onset. To counteract *IV2, ASSIM must outrank it, as well as outranking RESIST 2 to allow underlyingly IV1 segments to become IV2. The ranking that yields the Dutch case is given in (21)

(21) Ranking of assimilation, neutralization and faithfulness in Dutch

a. STAY 2-onset, ASSIM >> *IV2 >> STAY 2, RESIST 2
b. RESIST 3, STAY 3 >> IDENTICAL >> *IV2 >> ADJACENT

(21a) gives the basic ranking that results in ASSIM causing assimilation between obstruents at the cost of *IV2, which calls for neutralization. (21b) gives the ranking that keeps sonorants from triggering (or taking part in) assimilation. ASSIM is here more accurately referred to as IDENTICAL, and its companion

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[11] It is precisely this duplication of results between assimilation and neutralization that Lombardi (1991) wishes to avoid by regarding [voice] as a privative feature and thus making assimilation to [–voice] impossible. If assimilation and neutralization are implemented by rules, then two rules which make obstruents voiceless in the same environment are required, which seems redundant. Within the present Optimality theoretic analysis, the neutralization and assimilation constraints also sometimes cause the same results. Unlike the rules, however, neither the neutralization nor the assimilation constraint states that voicelessness is the required outcome. Voicelessness results from assimilation due to a constraint that demands identity of the IV values (whatever they may be). In neutralization, the selection of voicelessness is independent of the constraint that drives the neutralization, arising instead from the ranking of the specific faithfulness constraints. See also Chapter 2.3.2 and 2.3.3 for discussion of privativity.

constraint, ADJACENT, is shown to rank below *IV2, disabling the attractive force of ADJACENT. The tableaux in (22) illustrate the rankings in (21).

(22) Assimilation beats Neutralization in Dutch obstruents

a. Voiced coda, voiced onset ⇒ voicing retained

/…z b…/	ASSIM	*IV2	STAY 2	RESIST 2
√ z.b		**		
s.b	*!	*	*	

b. Voiced coda, word-finally ⇒ devoicing

/…z#/	ASSIM	*IV2	STAY 2	RESIST 2
z#		*!		
√ s#			*	

c. Voiceless coda, voiced onset ⇒ voicing

/…k d…/	ASSIM	*IV2	STAY 2	RESIST 2
√ g.d		**		*
k.d	*!	*		

d. Voiced coda, sonorant onset ⇒ devoicing

/…z n…/	RESIST 3	IDENTICAL	*IV2	ADJACENT	STAY 2
z.n		*	*!		
r.n	*!				*
√ s.n		*		*	*

The above tableaux show the disablement of *IV2 by ASSIM in (22a) and (c). Assimilation to IV2 (or retention of IV2 under assimilation) occurs at the cost of extra violations of *IV2, (the IV2 value in the onset being preserved by STAY 2-onset, not shown). In (22b) assimilation is irrelevant, so *IV2 emerges and forces neutralization. In (22d) *IV2 also plays a decisive role. Since ASSIM (IDENTICAL) is disabled in the case of obstruents before onset sonorants, the case falls to *IV2, since it dominates the attraction-causing constraint ADJACENT.

This section has shown that *IV2 may be active in a language even when its effects are partially masked by the action of a dominating ASSIM (as well as STAY 2-onset). The markedness constraint *IV2, which rules out the marked middle value of the IV scale, is a ranked, violable constraint like any other in an OT framework.

4.7 Conclusions

This chapter has presented a brief exploration of markedness effects within the context of the IV scale. The non-contextual markedness of the voiced obstruents is due phonologically to the fact that the presence of the middle value of the scale does not permit a maximal, binary distinction. The markedness of the IV2 value has been shown to have a number of consequences. First, it means that epenthesis (which looks only to markedness, not to faithfulness) will involve IV1 and IV3 segments, and not IV2.

Other applications of *IV2 involve the faithfulness constraints discussed in previous chapters. If *IV2 outranks STAY 2-onset and the general STAY 2, then IV2 segments will be disallowed except in the presence of high-ranked contextual markedness or assimilation constraints that contradict *IV2 in a particular environment. The ranking of the specific faithfulness constraints, i.e. RESIST 3 >> RESIST 2 >> RESIST 1, means that an input IV2 segment will neutralize to an IV1 segment when forced to by *IV2. The voicelessness that results from neutralization need not therefore be seen as a lack of phonological structure, as in previous approaches that have regarded [voice] as a privative feature. Instead, the voicelessness is due to the faithfulness constraints that refer to the scale.

The *IV2 constaint causes coda neutralization when the general STAY 2 constraint is dominated but the STAY 2-onset is not. Because of the positional faithfulness constraints, both *IV2 and the ASSIM constraint frequently cause changes in codas. The two constraints are in agreement if a coda contains a voiced obstruent and the following onset does not. In this case both constraints demand the removal of the IV2 value. In other cases, however, the two constraints are not in agreement. If *IV2 outranks ASSIM (and, of course, STAY 2), then neutralization will occur and assimilation will not (except that neutralization will satisfy ASSIM if the following onset is voiceless). Such is the case in German. If ASSIM outranks *IV2, then assimilation will occur where appropriate (before a following onset), and neutralization will occur elsewhere (word finally, and possibly before sonorants, depending on the ranking of ADJACENT). This is the case in Dutch.

The relative faithfulness constraints also interact with *IV2, as discussed in 4.4 (and in 3.4.2). Under coalescence of IV1 with IV3, *IV2 may be violated due to the higher ranking of *NON-ADJACENT. It is then better to stay close to both inputs, averaging out at IV2, than to obey *IV2.

The markedness of IV2 as the middle of the scale serves to explain why voiced obstruents are more frequently referred to in the phonology than are voiceless obstruents. Such constraints as *IV2 refer to voiced obstruents in the absence of constraints such as *IV1 referring to voiceless obstruents. The lack of reference to IV1 has been taken as evidence for the privativity of [voice] (Lombardi 1991). In a privative [voice] model voiceless obstruents have no [voice] node, so their voicing status can not be referred to by the phonology. In the present framework, voicelessness does have a specification, namely IV1. The markedness constraints of OT will constrain the appearance of the non-contextually marked IV2. In certain contexts, however, IV1 will be referred to, as

Pater (1995) shows. The *N+IV1 constraint refers to voicelessness and forbids it in a particular context. This means that IV1 must be an independent value which the phonology makes reference to. The fact that IV2 is non-contextually marked, however, means that it will be more active.

CHAPTER 5

TERNARY SCALES: EXTENSIONS, SPECULATIONS AND CONCLUSIONS

When you read you begin with A, B, C,
When you sing you begin with Do, Re, Mi.
Do, Re, Mi (Do, Re, Mi)
The first three notes just happen to be
Do, Re, Mi (Do, Re, Mi) —
Do Re Mi Fa So La Ti...
Let's see if I can make it easier…
Oscar Hammerstein II, *The Sound of Music*

5.1 Introduction and Summary

The body of this dissertation has been devoted to the Inherent Voicing Scale, and the constraints that refer to it. Chapter 2 presented one set of faithfulness constraints which refer to the ternary IV Scale. These faithfulness constraints were the specific faithfulness constraints, which refer to the individual values on the scale. The more prominent the scale value, the more faithfulness it demands, yielding the faithfulness subhierarchy of STAY 3, RESIST 3 >> STAY 2, RESIST 2 >> STAY 1, RESIST 1. These faithfulness constraints interact with the ASSIM constraints, so that assimilation between obstruents is common, but assimilation involving sonorants is rarer. The ternary nature of the scale was displayed both in the dominance order of the faithfulness constraints and in the ASSIM constraints, which had IDENTICAL and ADJACENT subparts. While IDENTICAL demands identity of scale values between assimilation target and trigger, ADJACENT demands only that their scale values be adjacent.

Chapter 3 explored a further type of faithfulness constraints which refer to a ternary scale. IDENT [X] is violated by output values which are adjacent (differing by one) from the input, while IDENT-ADJ [X] is violated by output values which are separated on the scale from the input values by an intervening scale value. While the specific faithfulness constraints refer to particular values on the scale, the relative faithfulness constraints refer to the relations between scale values. The relative faithfulness constraints were shown to be at work in cases of chain shift and 'averaging' coalescence. A variety of chain-shifting consonant mutations thus received a unified analysis.

Chapter 4 described the consequences of markedness on the scale. The middle value of the scale—IV2—is the most marked, non-contextually, since it is the presence of the middle value of the scale that prevents it from being a simple maximal binary distinction. Just as assimilation constraints were shown to interact with the ternary faithfulness constraints in Chapter 2, the neutralization constraint *IV2 was shown to do so in Chapter 4. In Chapter 2 a single set of ASSIM constraints evaluated all coda-onset pairs, while the specific faithfulness constraints adjudicated whether a given coda would assimilate or not. In Chapter 4 a single *IV2 constraint ruled out IV2 in codas, while the specific faithfulness constraints determined that the output of neutralization should be voiceless. Neutralization is not seen as the loss of structure, merely the avoidance of the marked scale value (and thus the marked—i.e. ternary—scale shape). Assimilation and neutralization can interact, with assimilation proceeding where applicable and neutralization elsewhere.

Assimilation and neutralization agree in forbidding voiced obstruent codas before voiceless obstruent onsets. In rule-based theories this creates a redundancy: the loss of a [voice] node and the assimilation to [–voice] both result in [–voice]. This redundancy has been used (Lombardi 1991) to support a privative theory of [voice], in which assimilation to [–voice] is impossible, and apparent assimilation to [–voice] is simply neutralization. The present theory does not represent neutralization as the loss of a node. It is the replacement of the marked IV2 value by IV1, the most easily added IV value. There is therefore no harm in referring to the IV1 value, and assimilation to IV1 is not a redundant process. Appeals to concepts of 'fusion' and 'final exceptionality' to explain why assimilation to [–voice] does not always look like neutralization (since it fails before voiced obstruents (fusion) and word-finally (final exceptionality)) are not necessary in the present approach. Assimilation and neutralization are both retained, as they are driven by distinct constraints, although they interact with the same faithfulness constraints.

As stated above, the theory summarized in the above paragraphs has been developed in the preceding chapters with explicit reference to the Inherent Voicing Scale. Although the remaining binary features can be subsumed into the ternary scales framework by making them binary scales, it would be odd if the IV scale were the only ternary scale among a mass of binary ones. I claim that there are in fact other ternary scales. The present chapter presents a brief overview of other scales, extending the theory to include certain other scales, and speculating on the possibility of extending it to yet others.

First, I propose that there are two other scales besides the IV scale previously discussed. The first is that of Consonantal Stricture (CS), and the second is that of Vowel Height. (VH). (The term 'consonantal' is used for the first scale, to distinguish it from Vowel Height, since vowel height is a type of stricture as well.) The two scales are shown in (1), in order of lowest to highest sonority, as in the IV scale.

(1) Consonantal Stricture and Vowel Height Scales

stop	fricative/liquid	vocoid/laryngeal	= Consonantal Stricture
CS1	CS2	CS3	
HIGH	MID	LOW	= Vowel Height

(for numerical VH values, see 5.4 below)

Multivalued features for stricture have been previously proposed by Williamson (1977), Ladefoged (1971, 1975), Rivas (1977), Foley (1977) and Steriade (1993). Multivalued features for vowels are proposed by Saltarelli

(1973), Rivas (1977) and Clements (1991). As Rivas points out for both stricture and vowel height (and Saltarelli discusses for vowel height), binary features predict the presence of a fourth class of stricture and vowel height, namely $\begin{bmatrix} -\text{continuant} \\ -\text{consonantal} \end{bmatrix}$ and $\begin{bmatrix} +\text{high} \\ +\text{low} \end{bmatrix}$. The fact that binary features do not combine to give the predicted four classes is evidence that the binarity of the features is inaccurate. Like voicing, consonantal stricture and vowel height are best represented on ternary scales.

The present approach seeks to provide voicing, stricture and vowel height with a unified treatment. This chapter lays out a rough outline of how this can be done, but also includes the areas in which the CS and VH scales are more difficult to model than is the IV scale. Section 5.2 looks at attraction and assimilation on the CS scale, comparing spirantization of stops to voicing of obstruents. Section 5.3 turns to chain shift on the CS scale, which is found in lenition systems. In many ways lenition can be given an analysis similar to eclipsis. Section 5.4 looks at assimilation, attraction and chain shift in vowel height. The VH scale appears to have a reversed hierarchy of faithfulness from the other, consonant-oriented scales in that the low sonority value receives the highest faithfulness. In other respects, the scalar analyses are easily applied to the VH scale. The possibility of more than three height values is also considered. Section 5.5 deals with markedness and neutralization on the CS and VH scales. Like IV2, the middle values of CS and VH are the marked ones, and neutralization of these values occurs. Section 5.6 shows how the IV, CS and VH scales can be combined to derive the Sonority Hierarchy. Section 5.7 briefly considers the possibility of other scales, and Section 5.8 concludes.

5.2 Attraction and Assimilation on the Consonantal Stricture Scale

Just as voiceless obstruents sometimes become voiced obstruents through attraction toward sonorants on the IV scale, stops are sometimes attracted toward vowels, becoming fricatives. This is the case in the Iberian languages (Mascaró 1984, 1991). After a vowel or a fricative, voiced stops are realized as fricatives. Data in given in (1) for Spanish, but Basque and Catalan exhibit similar patterns.[1] In the left column are environments where spirantization does not occur: word-initially, after a nasal, and in *d* after *l*. In the right column are spirantizing environments: after a vowel, after a fricative, after *r*, and in *b* and *g* after *l*.

(1) Spanish spirantization (Mascaró 1984)

bweno	'good'	kaβeλo	'hair'
eŋgaño	'cheat'	dizγusto	'trouble'
kaldo	'broth'	kurβa	'curve'
		kalβo	'bald'

In scalar terms, voiced CS1 becomes CS2 after CS2 or CS3. This is a typical case of attraction that is well described in a ternary framework. Given that RESIST CS3 will by nature be high ranking, it is not surprising that the stop does not assimilate all the way to the vocoid. Furthermore, in becoming a glide a stop would also violate RESIST IV3. The IDENTICAL constraint therefore can not be satisfied in the case of a triggering vowel, but it can be satisfied in the case of the fricative, since RESIST CS2 is lower ranked. Full assimilation to fricatives occurs, but only attraction toward the vowels. In an attraction context such as this, ADJACENT ranks above RESIST CS2, so that a CS1 segment will become CS2 in order to become adjacent to CS3. The ranking is given in (2). RESIST 3 can be

[1] Catalan has the additional feature of neutralization syllable-finally, so that the spirantization only occurs when the targetted segment is an onset. See 5.3 below for neutralization on the CS scale. The Catalan case is one of assimilation mixed with neutralization, similar to the case of Dutch IV assimilation and neutralization discussed in 4.6.

either RESIST CS3 or RESIST IV3, since either will prohibit the derivation of a glide from a voiced stop.

(2) Ranking to yield CS attraction

RESIST 3 >> IDENTICAL >> ADJACENT >> RESIST CS2 >> STAY CS1

The ranking in (2) is illustrated in (3). STAY CS1 is left out for reasons of space.

(3) Spanish attraction

a. Vowel + stop ⇒ fricative

/…ab…/	RESIST 3	IDENTICAL	ADJACENT	RESIST CS2
ab		*	*!	
aw	*!			
√ aβ		*		*

b. Fricative + stop ⇒ fricative

/…zg…/	RESIST 3	IDENTICAL	ADJACENT	RESIST CS2
zg		*	*!	
√ zγ		*		*

In (3a) the complete faithfulness of the first candidate and the complete assimilation of the second candidate are ruled out by the force of the assimilation constraints and RESIST 3 respectively. Attraction, which satisfies ADJACENT, though not IDENTICAL, is the necessary compromise. In (3b) full assimilation to a fricative can occur without violating RESIST 3.

The ternary scales model allows vowels to have an attracting influence on stops without having to give the vowels the same stricture feature as fricatives. Because the vowels and the fricatives are both higher on the CS scale than are the stops, they exert an assimilating influence in the same direction. Because they have different CS values, however, they are not expected to behave the same in all cases. This is an improvement over using a single [+continuant] feature which both vowels and fricatives share. A [+continuant] feature would either see vowels and fricatives as the same, or would have to be underspecified in vowels for some portion of a derivation. In a non-derivational framework the underspecification approach is not an option. Using a ternary CS scale resolves the problem.

An analysis using the CS scale is not without issues to resolve, however. In the present example of Iberian spirantization a chronic question has been why laterals behave as both continuants and stops. As shown above in (1) for Spanish, laterals trigger spirantization in labials and velars (thus acting as CS2) but not in coronals (thus acting as CS1). There is therefore a contrast between *kaldo* 'broth' and *kalβo* 'bald'.

The ambivalent behavior of laterals leads Mascaró (1991) to propose that Iberian spirantization is phonetic, and that laterals are phonetically continuant (given the presence of airflow) at the labial and velar places, but not at the coronal place, since the airflow is blocked there. I claim that the lateral behavior does not force a phonetic interpretation of Iberian spirantization. Instead I follow Padgett (1995) who analyzes the *ld* sequence as place-linked and therefore [continuant]-linked. In scalar terms, both elements of the *ld* sequence have the value CS1. Iberian laterals assimilate to following coronals, and so can take on different CS values *phonologically* depending on their context. So laterals before coronal stops are CS1, and elsewhere CS2. The analysis presented above then holds.

Other puzzles remain. For one thing, the above analysis does not explain why Iberian spirantization is restricted to voiced stops, leaving the voiceless stops unalternating. While there may be something in the fact that in these languages voiceless stops contrast with voiceless fricatives but voiced stops do not contrast with voiced fricatives, a worked-out theory of contrast in phonemic inventories is lacking at this point.

A further obstacle to a clear parallel between voicing assimilation and stricture assimilation is that voicing assimilation is relatively common, while stricture assimilation is less common. One reason for a paucity of CS assimilations may lie in the associations between place and stricture, examined by Selkirk (1991) and Padgett (1991, 1994). Since a segment can not have place without stricture (and/or *vice versa*), stricture and place can not be fully separated. Constraints on CS assimilations may therefore be complicated by constraints on place. The presence of place concerns in stricture assimilations may be at the root of another problematic aspect of stricture assimilations. Unlike the Iberian languages, other languages, such as Tiberian Hebrew (Selkirk 1991, McCarthy 1981, Leben 1980, Prince 1975), spirantize stops only after a vowel. There is therefore attraction of stops toward vowels, but not assimilation of stops to fricatives. This pattern is not expected given the ranking of the assimilation and faithfulness constraints, but may well be the result of the interaction between place and stricture. If consonantal place and vocalic place features are encoded in separate places in the feature geometry (as in Clements' (1991b)) or separately in some other way, then vowel place features do not interact with consonantal place features the way consonantal place features interact with each other (as pointed out by Ní Chiosáin & Padgett (1993)). A lack of interaction between place features may open the way for more interaction between stricture features in vowels and consonants. More work would be needed to confirm and formalize this conjecture, however.

This section has sought to draw parallels between attraction and assimilation on the IV scale and the same processes on the CS scale. Stricture assimilation and attraction are driven by the IDENTICAL and ADJACENT constraints, just as on the IV scale. Assimilation and attraction on the CS scale are restricted by the STAY and RESIST faithfulness constraints, again like on the IV scale. The general ternary framework holds. A number of confounding factors occur, however, especially in the area of place-stricture interaction.

5.3 Lenition: Chain Shift on the Consonantal Stricture Scale

The CS scale, like the IV scale, is the site of morphologically driven consonant mutations. Lenition mutations are characterized generally by a loss of stricture. In Irish, for example, most stops become fricatives, and *s* becomes *h*. The mutation is triggered in certain morphosyntactic environments. In cases such as Irish where the historical trigger for lenition is known, the mutation originated as a process affecting consonants intervocalically (Ultan 1970). Like eclipsis, lenition in Irish can be analyzed as the affixation of a morpheme which consists of only an underspecified segment. While the eclipsis morpheme contains the IV3 value, the lenition morpheme contains CS3, the value for vocoidal stricture on the Consonantal Stricture scale.

As in chapter 3, the lenition is forced by the MORPH REAL constraint, and guided by the relative faithfulness constraints IDENT [X] and IDENT-ADJ [X]. Markedness constraints and faithfulness constraints on specific features (such as [strident]) also play a role. I turn now to the actual lenition pattern of Irish.

5.3.1 Irish: Basic Chain Shift

Irish has a lenition mutation as well as an eclipsis mutation. The table in (4) lists the word-initial radical consonants. This table is like that in (15) in 3.3.1, but it gives in parentheses tense coronal sonorants for the dialect that requires word-initial coronal sonorants to be tense.

(4) Irish Consonants: Radical Initial (Ní Chiosáin 1991)

p p'	t t'	k k'	
b b'	d d'	g g'	
f f'	s s'		h
m m'	n n' (N N')		
	l l' (L L')		
	r r' (R R')		

These initial consonants undergo lenition in past tense verbs, in stems preceded by a prefix or the first element of a compound, or in a noun preceded by certain possessive pronouns, certain determiners, or by the cardinal numbers two through six (Ní Chiosáin 1991). The lenition results in the changes shown in (5).

(5) Lenition in Irish

Radical ⇒	Lenited	Radical ⇒	Lenited	No Change
p, p'	f, f'	f, f'	Ø, Ø'	
t, t'	h, h'	s, s',	h, h'	h
k, k'	x, x'			
b, b'	w/v, v'	m, m'	w/v, v'	
d, d'	ɣ, j/ɣ'	(N, N')	(n, n')	
g, g'	ɣ, j/ɣ'	(L, L', R, R')	(l, l', r, r')	

Some comments on the table in (5) are in order. When leniting, the *f* deletes, shown by the 'Ø'. However, the palatalization of the palatalized *f'* stays behind, and will show up on the final segment of a preceding article.

The voiceless labial and velar stops lenite to voiceless fricatives, while the voiceless coronal stops and fricatives become *h*. The voiced stops lenite to voiced fricatives and/or glides. The extent to which the fricative or glide variants occur apparently varies with dialect.

The labial nasal lenites to a labial fricative/glide. In dialects that require radical initial coronal sonorants to be tense, the coronal sonorants lenite to lax sonorants. In dialects that do not distinguish tense and lax sonorants the coronal sonorants are unaffected by lenition. In all dialects, *h* is unaffected.

Examples of Irish lenition are given in (6)

(6) Irish lenition (Ní Chiosáin 1991)

a. Voiceless stops

k'ark (cearc) 'a hen'	mə **x'**ark (mo chearc) 'my hen'		ku:g' **x'**ark (cúig chearc) 'five hens'	
ku:l (cúl) 'back'	+	**k**an't' (caint) 'talk'	⇒	ku:l**x**an't't 'gossip'
in'- (in) '-able'	+	**p**o:stə (pósta) 'married'	⇒	in'**f**o:stə (inphósta) 'marriageable'
t'ax (teach) 'a house'		mə **h'**ax (mo theach) 'my house'	t'r'i: **h'**ax (trí theach)	 'three houses'

b. Fricatives

f'i:əcəl' (fiacail) 'a tooth'	mə **i**:əkəl' (mo fhiacail) 'my tooth'	t'r'i: **i**:əkəl' (trí fhiacail) 'three teeth'
s'o:l (seol) 'sail'	**h'**o:l 'sailed'	

c. Voiced stops

do- (do) NEG	+	**d'**e:ntə (déanta) 'done'	⇒	do**j**e:ntə (dodhéanta) 'impossible'
il'- (il) 'multi-'	+	**g'**n'e:həx (gnéitheach) 'faceted'	⇒	il'**ɣ'**n'e:həx (ilghnéitheach) 'multifaceted'
mo:r (mór) 'big'	+	**b'**aləx (bealach) 'a way'	⇒	mo:r**v'**aləx (mórbhealach) 'a highway'

d. Sonorants

ma:lə (mála) 'a bag'	mə **w**a:lə (mo mhála) 'my bag'	t'r'í: **w**a:lə (tri mhála) 'three bags'

Irish lenition, like Irish eclipsis, has been the topic of many analyses, such as Kelly 1989, Ní Chiosáin 1991, Swingle 1992, Grijzenhout 1995. According to

Ní Chiosáin (1991), Irish lenition is brought about by rules of coronal delinking and spirantization, with a default deletion rule for the deletion of *f*. In this analysis the lenition is brought about solely by rule, and not by the addition of a morpheme. Kelly (1989), on the other hand, analyzes Irish lenition as triggered by a morpheme which consists of a [+continuant] autosegment. Swingle (1992) takes another view of the affixed morpheme, suggesting that it contains [coronal] and [–continuant], thus triggering dissimilation in stops and coronals. For Grijzenhout (1995), like Ní Chiosáin, the lenition is caused by a morphologically triggered rule. Working within Steriade's (1993) aperture theory, she analyzes lenition as the deletion of an aperture node.

The present theory sees Irish Lenition as brought about by an affix, as do Kelly and Swingle. Rather than possessing a value of [continuant], however, the affix has a value on the ternary Consonantal Stricture scale. Like Steriade (1993), I claim that there are three basic stricture types: stop, fricative, and non-consonantal (here CS1, CS2, CS3, cf. Steriade's A_0, A_{fric}, and A_{max}). The important difference between Steriade's Aperture theory and the Consonantal Stricture scale is that the values on the CS scale are ordered with respect to each other. In other words, they participate in the adjacency relation, which is referred to by the relative faithfulness constraints.

Consider first the (non-coronal) voiceless stops. They become voiceless fricatives. An input segment with value 1 on the CS scale corresponds to an output segment with value 2. This is, I claim, the result of coalescence with the lenition morpheme (L), which carries the value CS3. Like the eclipsis morpheme of the previous chapter, the L is underspecified and must undergo coalescence to have a syllabified output correspondent. The coalescence of CS1 and CS3 leads to CS2, since an output with CS2 violates only IDENT [CS] (twice) and not IDENT-ADJ [CS]. This is shown in tableau (7). The averaging coalescence that derives fricatives (CS2) from stops (CS1) plus L (CS3) is analogous to the averaging coalescence that yields voiced obstruents (IV2) from voiceless obstruents (IV1) plus M (IV3), discussed in Chapter 3.

(7) Lenition of (non-coronal) voiceless stops in Irish

L + k	MORPH REAL	IDENT-ADJ [CS]	IDENT [X]
a. k	*!		
b. h		*!	
c. √ x			**

In tableau (7) the first candidate retains its CS1 value, but this violates MORPH REAL (the constraint introduced in 3.3 which demands that a morpheme have a surface phonological effect) since the L morpheme has had no surface effect. The (b) candidate realizes the L morpheme, taking on L's CS3 stricture. This violates IDENT-ADJ [X], however, since CS3 is too far from the /k/'s CS1. The optimal candidate is the one that violates only IDENT [X], although it violates it twice. The winner is therefore the fricative, with value CS2.

The voiced (non-coronal) stops and *m* behave much the same as the voiceless ones. Stops become fricatives, in a classic case of averaging coalescence. An exception to the general pattern occurs in that the outputs of the voiced stops in some cases alternate between glides (CS3) and fricatives(CS2). According to Ní Chiosáin (1991) the glides arise through an independent process of glide formation that operates on *v* and ɣ′ after these are formed by lenition. In a non-serial framework, the glides must be formed concurrently with the fricatives. The fricatives *v* and ɣ′ are presumably ruled out in certain environments by a constraint that outranks IDENT-ADJ [CS] but not MORPH REAL. The result is that MORPH REAL still demands that L be realized, but that since these fricatives are not appropriate outputs, MORPH REAL must have some other realization. The fricatives lose to the glides, which violate IDENT-ADJ [CS], but not the constraint against voiced fricatives. This is illustrated in tableau (8). I leave aside the question of exactly why and in what exact environments *v* and ɣ′ are ruled out, using a stand-in constraint of '*v,ɣ'/environment'.

(8) Lenition of voiced stops to glides in Irish

L + g'	MORPH REAL	*v,ɣ'/ environment	IDENT-ADJ [CS]	IDENT [X]
a. g'	*!			
b. ɣ'		*!		**
c. √ j			*	

If the environment of the '*v,ɣ'/environment' constraint does not hold, voiced fricatives will of course be derived, satisfying IDENT-ADJ [CS], but violating IDENT [CS] twice, as in the lenition of voiceless stops shown in tableau (7).

The coronal fricatives (*s* and *s*′) behave just like the voiceless stops in that they move one step on the CS scale. They become *h* and *h*′, which are non-consonantal in their stricture, and voiceless like *s* and *s*′. The lenition of *s* (CS2) to *h* (CS3) is analogous to the eclipsis of voiced obstruents (IV2) to nasals (IV3). The lenition of /s/ is shown in tableau (9). In becoming *h*, /s/ violates IDENT [CS] once in order to satisfy the higher-ranked MORPH REAL.

(9) Lenition of /s/ in Irish

L + s	MORPH REAL	IDENT-ADJ [CS]	IDENT [CS]
a. s	*!		
b. √ h			*

The tableau in (9) shows the basic interaction between MORPH REAL and the relative faithfulness constraints. In order to rule out the formation of a glide here, as opposed to the *h*, it is sufficient to rank STAY [coronal] relatively low, and rank IDENT-ADJ [IV] relatively high. In becoming *h*, /s/ loses its [coronal] value, which it could avoid by becoming *j*. Becoming *j*, however, would be a non-adjacent move on the IV scale (IV1 to IV3), and is thus avoided. Given the high ranking of IDENT-ADJ [IV], and given the ranking in (9), the lenition of a voiceless fricative to *h* is the expected result of a mutation caused by a CS3 segment, since that it realizes the morpheme with a minimal (adjacent) unfaithfulness on the CS scale.

The coronal stops are an interesting case, since they do not simply become fricatives. The voiceless coronal stops (*t* and *t'*) become *h* and *h'*, like the voiceless coronal fricatives do. Given the nature of the relative faithfulness constraints, the expected outcome from *t* would be θ or *s*. θ does not appear in Irish, so we can assume that it is ruled out by a constraint that outranks IDENT-ADJ [CS]. The ranking of *θ over IDENT-ADJ [CS] has the result that /t/ prefers to take a non-adjacent movement (to *h*) rather than become θ. The other coronal fricative that *t* could become is *s*. This also does not happen. Presumably *s* is not simply the fricative version of *t*. It has an added [strident] feature that *t* does not possess. By a high ranking of RESIST [strident], *s* is ruled out as the lenition outcome of /t/. Rather than violate RESIST [strident] or *θ, the /t/ makes a non-adjacent move on the CS scale to satisfy MORPH REAL. This is shown below.

(10) Lenition of *t* in Irish

L + t	MORPH REAL	*θ	RESIST [strident]	IDENT-ADJ [CS]	IDENT [CS]
a. t	*!				
b. θ		*!			**
c. s			*!		**
d. √ h				*	

The voiced coronal stops are in a similar position. A /d/ can not become ð because ð is ruled out like θ is. It can not become *z* because it may not become strident, and also because *z* is ruled out by a high ranking constraint (as shown in Chapter 3.3.1). The situation is not entirely like *t*'s, however, since *t* could simply make a non-adjacent move on the CS scale and become *h*. Since *d* is voiced, a non-adjacent move would create a voiced laryngeal, not surprisingly ruled out. Instead, it shares the fate of /g/, becoming ɣ, while /d'/ (with /g'/) becomes *j*~ɣ′. The derivation of ɣ from L plus /d/ is shown in tableau (11).

(11) Lenition of /d/ in Irish

L + d	MORPH REAL	*ð, z, ɦ	RESIST [Dorsal]	IDENT-ADJ [CS]	IDENT [CS]
a. d	*!				
b. ð		*!			**
c. z		*!			**
d. ɦ		*!		*	
d. √ ɣ			*		**

The tableau in (11) does not list STAY [Coronal] among its constraints: this is violated in all cases of lenition in coronal obstruents. It must be low ranking, as it never decides between lenition candidates. The ranking between RESIST [Dorsal] and IDENT-ADJ [CS]is asserted in tableau (11), but not proved. The reason for the ranking is that since /t/ does not lenite to *x* (in most dialects), we can assume that the non-adjacent move made by the /t/ is preferred to an adjacent move made which requires the addition of a Dorsal place. Given the ranking between RESIST [Dorsal] and IDENT-ADJ [CS], we might expect to always find a glide as the lenited version of /d/ rather then a dorsal fricative. The *j* glide is the (usual) lenition output for /d'/ and /g'/, however, but not the output for /d/ (or /g/). The important difference between /d/ and /d'/ is palatalization—*j* is presumably inherently palatalized, so for /d/ to become *j* would require the addition of palatalization, which is prohibited.

In the labial oral and nasal stops, fricative and glides are produced by lenition. /b/ and /m/ become *w*/*v* and /b'/ and /m'/ become *v'*. Only the non-palatalized (velarized) labials become *w*, just as only the palatalized coronals and dorsals become *j*. A palatalized *w* presumably does not exist. When the labial nasals lenite to labial fricatives and glides, they increase their CS value, but they also lose their nasality (in certain dialects), and sometimes their IV3 value. This is shown in tableau (12).

(12) Lenition of m' in Irish

L + m'	MORPH REAL	STAY [nasal]	IDENT [IV]	IDENT [CS]
m'	*!			
√ v'		*	*	*

The laryngeal *h* does not lenite in Irish (nor in any language of the sample referred to in 5.3.2). This is because it already has the specifications of L. It is already a CS3 segment. As in the case of nasal consonants in eclipsis, there is nothing MORPH REAL can do to cause a surface effect of L on an *h*, so lenition is doomed to failure.[2]

[2]Lenition also fails in two other cases. First, it fails in s+stop and s+labial nasal clusters. There are two possible explanations for this, both mentioned by Ní Chiosáin (1991). One is that sonority constraints rule out the *ht*, *hk*, *hp* and *hm* clusters that would result if the /s/ were to lenite. Something to note, however, is that s+coronal sonorant clusters do lenite. As Ní Chiosáin points out, this would suggest a difference in sonority between *m* and *n*, since *hm* clusters are not permitted, while *hn* clusters are permitted under lenition. Another possibility may be related to the fact that the lenition fails in exactly those cases where there are *two* initial consonants that are lenitable. The other case in which lenition fails is in coronals which are preceded by a coronal-final proclitic. As Ní Chiosáin analyzes it, this is due to coronal fusion of the stem-initial segment with the preceding coronal. Since coronals must lenite by losing their coronal nodes, lenition is blocked in these cases. Sharing of coronal nodes also occurs in vowel-initial stems, which receive an epenthetic *t* when following a coronal-final proclitic, but an *h* otherwise.

To summarize the basic scalar behavior of the mutation, Irish lenition follows the general pattern of a stepwise movement along the CS scale under the pressure of the L morpheme. Exceptions to the stepwise movement occur when a CS2 landing site is unavailable, as in the 'glide-formation', or when *t* is forced become *h* because non-strident CS2 coronals are not permitted (cf. Welsh eclipsis in 3.3.4, where the IV1 stops were forced to take two steps on the IV scale because IV2 was ruled out).

An interesting further question concerns the labial fricatives *f* and *f'*. These segments appear to delete under lenition, but they do not entirely disappear, since the palatalization on *f'* survives and will show up on the final consonant of a preceding proclitic. While deletion might seem appropriate as a final resort of lenition, deletion does not occur in other segments which resist lenition, namely the coronal sonorants in those dialects that do not contrast tense and lax coronal sonorants. I leave the question of *f* deletion open.

Turning to the coronal sonorants, in some dialects these have both tense and lax versions. In radical initial position only the tense versions occur, while in lenited forms the lax versions occur. No change in stricture occurs, but the lax versions are shorter and laxer. While this might be considered degemination (as suggested by Ní Chiosáin (1991)), another possibility is that the tense and lax version are differentiated by a [tense/lax] feature. I pursue the latter possibility in the context of the next section.

5.3.2 Other Lenition Mutations and the Tense/Lax Question

As suggested by the tense coronal sonorants in Irish, lenition can be more complex than simple movement on the CS scale. An instructive case is that of Breton (Press 1986). Breton has the following consonants in initial radical position, where capital letters represent fortis sounds.

(13) Breton initial radical consonants

P	T		K	
B	D		G	G^W
M	N			
F	S	Š	X	
	L, R	y		

Lenition has the following effects on the consonants in (13).

(14) Lenition in Breton

Radical ⇒	Lenited	Radical ⇒	Lenited	No Change
P	b	B	v	
T	d	D	z	
K	g	G	γ	
		G^W	w	
M	v	F	vh	
N	n	S	z	
		Š	ž	y
		X	γ	
L	l	R	r	

In the chart above, *vh* is a lenis, weakly voiced labiodental fricative, intermediate between *f* and *v*. The *N, L,* and *R* are shown as leniting to a lax *n, l,* and *r*, however according to Press the lenition is difficult to perceive, as it is triggered by a preceding article whose final consonant is *n, l* or *r* according to environment.

The consonants in (14) shown in capitals are reported by Press to be tense, while those shown in lowercase letters are lax. Therefore, while voiceless obstruents lenite to voiced obstruents, the voiced obstruents that result from the lenition are not the same as the voiced obstruents that do not result from lenition. The lenited versions are described as lax, while the radical versions are tense in initial position.

Aside from the laxing and voicing of the voiceless obstruents, Breton lenition is much like Irish lenition in that stops become fricatives under influence from the L morpheme. Given the behavior of the voiceless obstruents, however, something else must be at work beyond an L morpheme consisting of CS3.

I provisionally propose that the lenition morpheme is associated with the [lax] value of a tense/lax feature, as well as being associated with the CS3 value. In order to be realized, a lenition output could either incorporate a shift to(ward) CS3, or it could take on the value [lax]. Breton voiceless obstruents are required to be tense, so a switch from [tense] to [lax] also involves a change from IV1 to IV2. The correlation of IV1 with [tense] may also be involved in other languages (such as Mende—see (15)), where voicing of IV1 segments is one effect of lenition. A switch of [tense] to [lax] is also at work in the Irish coronal sonorants, in certain dialects.

Lenition appears to work on two dimensions: the degree of stricture (on the CS scale) and the force or length of the stricture (indicated by [tense/lax]). What is lacking at this point is a model that represents the two dimensions of lenition in some unified way. The situation is only superficially like that of eclipsis, where the feature [nasal] was associated with IV3. It is obvious that [nasal] has a natural affinity for IV3, while it is not so obvious why [lax] patterns with CS3 in lenition. The [lax] feature does not associate only with CS3.

The laxing and the loss of stricture can not be subsumed under an increase in sonority. Lenition is not accomplished through just any increase in sonority. The following are increases in sonority that are not legitimate lenitions: *f → m, *v → m, *p → m, *b → m, *b → f. Nasals are not legitimate outputs of lenition because they are stops, with stricture CS1, even though they are very sonorant. Some legitimate lenitions are not increases in sonority, such as m' → v' in Irish.

Before concluding this speculative discussion of lenition, I include a brief survey of the different outputs of lenition. Like eclipsis, lenition takes many forms, both within and across languages. The different outcomes of lenition in various Celtic and Mande languages are given in (15).[3]

(15) Outcomes of lenition

A. Increase in CS value

stop becomes fricative (Irish, Welsh, Breton, Bandi)
CS1 → CS2

stop becomes *h* (Irish)
CS1 → CS3

stop becomes liquid (Mende, Bandi)
CS1 → CS2

stop becomes glide (Mende, Bandi)
CS1 → CS3

fricative becomes *h* (Irish, Bandi)
CS2 → CS3

B. Decrease in length or tension

'tense' consonant becomes 'lax' (Breton, Irish)
[tense] → [lax]

voiceless fortis stop becomes voiced lenis stop (Breton, Mende[4])
CS1, IV1 → CS1, IV2
[tense] [lax]

voiceless fricative becomes voiced fricative (Mende)
CS2, IV1 → CS2, IV2
[tense] [lax]

aspirated fortis liquid becomes plain lenis liquid (Welsh)
CS2 [+spread] → CS2 [–spread]
[tense] [lax]

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[3] Sources for the languages in (15) are, for Irish, Ní Chiosáin (1991); for Welsh, Ball & Müller (1992); for Breton, Press (1986); for Bandi, Heydorn (1941); for Mende, Innes (1962).

[4] On the basis of the above discussion of laxing, I assume that the voicing in Mende—like that in Breton— is associated with laxing.

voiceless aspirated fortis stop becomes plain voiceless lenis stop (Welsh)
CS1, IV1, [+spread] → CS1, IV1, [–spread]
[tense] [lax]

The lenition outcomes in (15) are divided into two types. In (15a) the lenition involves simply a movement on the CS scale. In (15b) the lenition involves some laxing or shortening of the segment. The outcome of lenition varies within languages as well as between languages. Within a language outcomes may come from both the (a) and (b) groups: all languages in the sample except Bandi have outcomes in both groups (at least for some dialects).

In each language there are some segments which are immune to lenition. As mentioned previously, *h* does not lenite in any language of the sample, but this is easily explained because it is a lax CS3 segment. In the dialects of Irish that do not distinguish tense and lax coronal sonorants, the coronal sonorants are immune to lenition. This is in keeping with other leniting languages. In Irish, Gaelic, Welsh and Breton, the only lenition of coronal sonorants that occurs is loss of tension and/or aspiration. Although the similarity among Celtic languages may be due to genetics, the Mande languages Mende and Bandi exhibit similar patterns in that sonorants and especially coronal sonorants may be immune to lenition. In Mende (Innes 1962) the pure nasals *m, n, ñ,* and ŋ are the only consonants other than *h* that do not lenite. (There are no initial radical liquids.) Prenasalized stops, on the other hand, are affected by lenition. In Bandi *m, ñ,* and ŋ and the prenasalized stops do undergo lenition, but the coronal *n* is immune. The reason for the tendency of (coronal) sonorants to resist lenition is unknown.

In conclusion, lenition, like eclipsis, appears to act on a ternary scale. Irish lenition was analyzed as coalescence of the stem-initial segment with an underspecified morpheme that contains the CS3 value. Certain problems remain unresolved, however. Lenition also appears to act on a [tense/lax] feature, as illustrated in (15) above. This means that the lenition morpheme could be realized by either laxing or a shift on the CS scale. The connection between [tense/lax] and the CS3 value remains unmotivated. Sonority was considered and rejected as a candidate for the connection between the two. Another unresolved issue is that of the deletion of some segments: *f(')* in Irish, and *k* in Welsh. While deletion might somehow be considered a last resort (in the face of an unrealizable L morpheme), such a solution leaves the question of why other unlenitable segments (*h*, coronal sonorants) do not lenite but simply remain unchanged in lenition contexts.

5.4 Attraction, Assimilation and Chain shift on the Vowel Height Scale

I turn now to the Vowel Height Scale (HIGH, MID, LOW), and present a brief outline of processes that occur on it. One process, that of averaging coalescence, has already been analyzed on the VH scale for Sanskrit in 3.4.1. In Sanskrit a low vowel plus high vowel coalesced to a long mid vowel, even though mid vowels were otherwise not permitted. In such a case the IDENT [VH] relative faithfulness constraint requires that the output not get too far on the VH scale from either input. This section looks at other scalar processes affecting vowel height, while also considering the obstacles remaining to fully implementing the scalar model for vowels. I will be looking at Basque and two dialects of Spanish. All data in this section comes from Hualde (1989).

5.4.1 Basque Attraction

Many dialects of Basque exhibit attraction of low vowels toward preceding high vowels. Thus an /a/ surfaces as *e* when it follows a high vowel. Hualde gives examples from the article /-a/, which becomes -*e* when the previous vowel is high. These are given in (16), where the attraction occurs in the right-hand column, after high vowels, but not in the left-hand column, after mid vowels.

(16) Basque attraction in low vowels

gison-a	'the man'	tš akur̄ -e	'the dog'
baś o-a	'the forest'	buru-e	'the head'
etš e-a	'the house'	mendi-e	'the mountain'
aker̄ -a	'the billygoat'	lapin-e	'the rabbit'

According to Hualde, the raising of /a/ is caused by spreading of [+high]. The result is $\begin{bmatrix}\text{+high}\\ \text{+low}\end{bmatrix}$, which is automatically reinterpreted as $\begin{bmatrix}\text{–high}\\ \text{–low}\end{bmatrix}$. The present ternary system does not need such stipulations. This is a straightforward case of attraction on a ternary scale.

The Basque case bring up a point that should be addressed before presenting the actual analysis of the attraction. In the attraction on the IV and CS scales, a least-prominent value (i.e. 1) took one step toward the most prominent value (i.e. 3). So voiceless obstruents (IV1) voiced in the environment of sonorants (IV3), and stops (CS1) spirantized in the environment of vowels (CS3). If scale-prominence is always assigned according to phonetic prominence, or sonority, then the situation turns upside down in Basque (and in Lena Spanish, in 5.4.3 below). In Basque the most prominent value (LOW) is attracting toward the least prominent value (HIGH).

One could argue that this is not attraction of the type considered in Chapter 2, where IDENTICAL is foiled by high ranking RESIST 3, and ADJACENT takes over. One could say instead that the low vowels only take one step on the scale due to the relative faithfulness constraint IDENT-ADJ [VH] which would prohibit full assimilation of LOW to HIGH. The problem with that, however, is that the raising of low vowels to mid in Basque is apparently not accompanied by the raising of mid vowels to high. If high vowels exert assimilatory force in

Basque, one would expect the mid vowels to feel it, except if they are prohibited from becoming HIGH by a high ranking RESIST HIGH.

Based on these facts of Basque, and on the behavior of vowels in Russian (discussed in 5.5.2 below), I tentatively propose that the VH scale has faithfulness reversed from the IV and CS scales. The faithfulness subhierarchy is thus as in (17). I use the words *HIGH*, *MID*, and *LOW*, rather the VH1, VH2, VH3, to avoid the equation of sonority with higher numbers, as in the IV and CS scales.

(17) Faithfulness on the VH scale

RESIST HIGH, STAY HIGH>>
RESIST MID, STAY MID>>
RESIST LOW, STAY LOW

The order in (17) requires some justification, in light of the argument made in 2.1.2 that higher prominence is correlated with higher faithfulness. The two scales examined thus far (IV and CS) are primarily used to distinguish between consonants, although vowels have IV and CS values too. The VH scale is solely used to distinguish between vowels. Although sonority, the segmental form of prominence, can be arranged on a single scale, it affects vowels and consonants in opposite ways. A highly sonorous consonant is a relatively poor consonant, but a highly sonorous vowel is a good vowel. Conversely, a consonant of low sonority is a good consonant, but a vowel of low sonority is a bad vowel. Since sonority affects vowels and consonants in opposite ways, it is not surprising that the relationship between sonority and faithfulness is also opposite in vowels.

A further point regarding the Basque data, is that although low vowels are attracted toward high vowels, they are not assimilated to mid vowels, as the left-hand examples in (16) demonstrate. In IV attraction such as that in Krakow Polish (discussed in 2.6), IV1 segments became IV2 before both IV3 and IV2.

Here in Basque the attraction occurs in the absence of assimilation. As this and the following sections should show, however, high vowels are particularly active in vowel assimilations. High vowels appear to trigger assimilations that other vowels do not. The factors that cause certain segments (especially ones with values at the top ends of the scales) to be assimilation triggers and others to be assimilation targets remains to be worked out in an OT framework.

In the Basque vowel attraction case, therefore, the high vowels are the only assimilation triggers. I note this in tableau (18) below with IDENTICAL-HIGH and ADJACENT-HIGH constraints. Assuming the faithfulness ordering of (17), the attraction occurs because full assimilation can't. This is because IDENTICAL does not outrank RESIST HIGH. The attraction can occur because ADJACENT outranks RESIST MID. The ranking is illustrated in (18).

(18) VH attraction in Basque

buru-a	RESIST HIGH	IDENTICAL-HIGH	ADJACENT-HIGH	RESIST MID
buru-a		*	*!	
buru-i	*!			
√ buru-e		*		*

As in other cases of attraction, complete faithfulness is out because it violates ADJACENT as well as IDENTICAL. Complete assimilation is out because it violates the highest-ranked RESIST constraint, here RESIST HIGH. Attraction successfully splits the difference between assimilation and faithfulness, in a way made sensible through the use of a ternary scale.

5.4.2 Pasiego Spanish Assimilation

While the presence of attraction suggests the operation of a phonological scale, the scalar model must also account for cases of simple assimilation that do not involve attraction. An analysis of such assimilations which occur on the IV scale was presented in Chapter 2, and the analysis can be easily carried over to the realm of vowel height. A relevant case is that of vowel assimilation in Pasiego Spanish. In the Pasiego dialect, stressed mid vowels become high when the final vowel is high. This is shown in (19a). Mid vowels raise, but low vowels do not, as shown in (19b). Underlying forms are determined by comparison with forms in the plural, feminine, and mass noun forms. The cited forms are masculine singular. Small capitals indicate centralized, [–ATR] vowels.

(19) Vowel Height assimilation in Pasiego Spanish (Hualde 1989)

a. Mid vowels raise

/negru/	nÍgrU	'black'
/kesu/	kÍsU	'cheese'
/gordu/	gÚrdU	'fat, thick'
/floxu/	flÚxU	'limp'

b. Low vowels remain

/blanku/	blÁnkU	'white'
/gatu/	gÁtU	'cat'

As in Basque, the raising is triggered by a high vowel. Here, however, mid vowels are affected and low vowels are not. Since mid vowels raise, we know that RESIST HIGHmust be dominated. The mid vowels satisfy IDENTICAL-HIGH through violation of RESIST HIGH. Since the mid vowels assimilate, violating RESIST HIGH, the inertness of the low vowels can not be attributed to interference from RESIST HIGH. Instead, the low vowels must be inert because IDENT-ADJ [VH] forbids them to assimilate fully. Unlike in Basque, where the ranking of ADJACENT-HIGH over RESIST MID brought about attraction, Pasiego must rank ADJACENT-HIGH below RESIST MID, making attraction impossible. The ranking is spelled out in (20).

(20) VH assimilation ranking in Pasiego

ID'T-ADJ [VH] >> IDENT'L-HIGH>> RES. HIGH>> RES. MID >> ADJAC'T-HIGH

By ranking of IDENT-ADJ [VH] over IDENTICAL-HIGH, low vowels are prohibited from assimilating all the way to the high vowels. By the ranking of IDENTICAL-HIGH over RESIST HIGH, mid vowels become high. RESIST HIGH outranks RESIST MID by definition, as in (17) above. RESIST MID outranks ADJACENT-HIGH so as to prevent the attraction of the low vowels. The ranking is illustrated in the following tableaux.

(21) Vowel Assimilation in Pasiego Spanish

a. Mid vowels assimilate to high

gordu	IDENT-ADJ [VH]	IDENTICAL-HIGH	RESIST HIGH	RESIST MID	ADJACENT - HIGH
gOrdU		*!			
√ gUrdU			*		

b. Low vowels are inert

gatu	IDENT-ADJ [VH]	IDENTICAL-HIGH	RESIST HIGH	RESIST MID	ADJACENT - HIGH
√ gAtU		*			*
gEtU		*		*!	
gUtU	*!		*		

Due to the ranking of IDENTICAL-HIGH over RESIST HIGH and the ranking of RESIST MID over ADJACENT-HIGH, the Pasiego Spanish assimilation turns out very differently than the Basque attraction. In fact, the Pasiego ranking is much like that referred to in (7f) in Chapter 3.2, repeated here.

(22) Ranking from 3.2, (8f)

IDENT-ADJ [X] >> IDENTICAL >> IDENT [X] >> ADJACENT

By the ranking in (22), IV1 would assimilate to IV2, and IV2 would assimilate to IV3, but no attraction or chain shift would occur. Assimilation only takes place if it is full assimilation and if it does not involve a shift of more than one on the scale.

If RESIST MID in (20) and (21) is replaced with IDENT [VH], the ranking for Pasiego would be equivalent to the ranking in (22). Indeed, the IDENT [VH] constraint could be what forestalls attraction of the low vowels. IDENT [VH], like RESIST MID, would serve the purpose of keeping low vowels from becoming mid. Since IDENT [VH] is outranked by IDENTICAL-HIGH, it would not interfere with the raising of mid vowels to high vowels.

The only problem with equating Pasiego Spanish with the ranking in (22) is that the ranking in (22) predicts two separate assimilations, one of value 1 to 2, and the other of value 2 to 3. On the VH scale that would imply LOW assimilating to MID only, and MID assimilating to HIGH only. Since only high vowels serve as assimilation triggers in the present process, the predicted assimilation of LOW to MID can not occur and the ranking can not be confirmed.

To summarize the Pasiego case, assimilation of mid vowels to high vowels occurs without attraction of the low vowels. The assimilation of the mid vowels is permitted by the ranking of IDENTICAL-HIGH over RESIST HIGH, while the attraction of low vowels is prohibited by the ranking of RESIST MID or IDENT [VH] over ADJACENT-HIGH. By the different rankings of ADJACENT, illustrated in Basque and Pasiego Spanish, the ternary scales model can account for both cases of attraction and cases of assimilation without attraction. The Pasiego case appears to fill in a gap in the paradigm introduced in Chapter 3.2, in that assimilation only occurs if it is total, and only if it involves moving only one step on the scale.

5.4.3 Lena Spanish Chain Shift

As with the other scales, the VH scale exhibits chain shift. A chain shift of LOW to MID to HIGH occurs in the Lena dialect of Spanish, as shown in (23). The affected vowel is the stressed vowel preceding the final vowel. Vowels intervening between the stressed vowels and the final vowel are unaffected. The underlying forms of the affected vowels are given by the feminine singular form.

(23) Lena Spanish Vowel Chain Shift (Hualde 1989)

masc. sg.	fem. sg.	
gétu	gáta	'cat'
séntu	sánta	'saint'
š énu	š ána	'diligent worker'
blénku	blánka'white	
péš aru	páš ara	'bird'
nínu	néna	'child'
kordíru	kordéra	'lamb'
ísti	ésta	'this'
síku	séka	'dry'
tsúbu	tsóba	'wolf'
kúš u	kóš a	'cripple'
silikútiku	silikótika	'suffering from silicosis'

According to Hualde, the assimilation of the stressed vowel in the absence of effects on intervening unstressed vowels shows that the assimilation occurs metrically (spreading to the first foot and so to its head) rather than autosegmentally. I accept this analysis, and turn to the question of the proper featural description of the process.

According to Hualde's analysis, the assimilation spreads [+high]. Mid vowels therefore become high. Low vowels also take on the [+high], becoming mid. As mentioned before, this requires the stipulation that $\begin{bmatrix}+\text{high}\\+\text{low}\end{bmatrix}$ be automatically converted to $\begin{bmatrix}-\text{high}\\-\text{low}\end{bmatrix}$. In the ternary scales model, the raising of the low vowels is more easily accommodated.

The Lena Spanish vowel raising is a simple case of chain shift, similar to the IV chain shift that occurs in southern Italian, and analyzed in 3.1–2. The basic analysis of Chapter 3 is easily transferred from the IV scale to the VH scale. Since RESIST HIGH is violated, we know that it is dominated by IDENTICAL-HIGH, and since RESIST HIGH is dominated, all the VH RESIST constraints are. It is therefore not the specific faithfulness constraints (of the STAY and RESIST type) that constrain the assimilation. It is the relative faithfulness constraints, as in Chapter 3. Each vowel can only move one step on the VH scale away from its underlying value. The IDENT-ADJ [VH] constraint forbids anything more. Unlike in Pasiego Spanish, however, low vowels become mid to satisfy ADJACENT-HIGH. This means that IDENT [VH] can be violated to satisfy ADJACENT-HIGH. The ranking responsible for the Lena Spanish chain shift is given in (24). The ranking is the same as that for the southern Italian IV chain shift discussed in 3.1–2.

(24) Ranking for Lena Spanish chain shift
IDENT-ADJ [VH] >> IDENTICAL-HIGH >> ADJACENT-HIGH>> IDENT [VH]

The fact that IDENT-ADJ [VH] outranks IDENTICAL-HIGH means that assimilation can only occur if the required movement is an adjacent one, involving only one step on the scale. IDENTICAL-HIGH outranks ADJACENT-HIGH by definition. ADJACENT-HIGH outranks IDENT [VH] because low vowels take one step on the scale to satisfy ADJACENT-HIGH at the cost of IDENT [VH]. The ranking is illustrated in (25).

(25) Lena Spanish Chain Shift
a. mid vowels become high

seku	IDENT-ADJ [VH]	IDENTICAL-HIGH	ADJACENT -HIGH	IDENT [VH]
seku		*!		
√ siku				*

b. low vowels become mid

gatu	IDENT-ADJ [VH]	IDENTICAL-HIGH	ADJACENT -HIGH	IDENT [VH]
gatu		*	*!	
√ getu		*		*
gitu	*!			

The ranking in the tableaux in (25) derives Lena Spanish chain shift. Mid vowel become high under the force of IDENTICAL-HIGH, while taking only one step on the scale. Low vowels can not become high because of the top-ranking of IDENT-ADJ [VH], which rules out the two step movement they would have to take in order to become high. They can however, satisfy ADJACENT-HIGH by taking only one step and becoming mid. As this section demonstrates, the ternary scales framework can account for an apparently complex process such as chain shift, as well as the assimilation and attraction of Pasiego Spanish and Basque. Furthermore, the VH chain shift of Lena Spanish receives an identical account to the IV chain shift in southern Italian. Certain obstacles to the ternary scales model of vowel height remain, however, as discussed in the next subsection.

5.4.4 Residual Questions

One question that this section on vowel height raises is related to one which is relevant to the IV scale, but has not yet been mentioned. In this section, all the height assimilations were triggered by high vowels. Thus all the assimilations were ones of raising, not lowering. Indeed, Parkinson (1995) states that partial lowering of high vowels (i.e. attraction of high vowels to mid in the presence of low vowels) is unattested.[5] To a certain extent this is a good thing, since simple attraction, governed by the STAY and RESIST constraints, is predicted not to occur in reverse. In other words, voiceless obstruents can voice before sonorants, but sonorants do not become voiced obstruents before voiceless obstruents. Similarly, low vowels can become mid before high vowels, but high

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[5] This may not be true, strictly speaking. Radhakrishnan (1981) reports that Nancowry unstressed high vowels are attracted toward stressed low vowels in fast speech, so that /wiák/ may be pronounced [weák]. The Nancowry attraction only occurs with strictly adjacent vowels, however, and Parkinson appears to be considering cases of vowel harmony which occur across syllables. A chain shift, with the mid vowels also lowering to low vowels, can not occur in Nancowry, since mid vowels do not otherwise occur in unstressed positions. See 5.5.2.

vowels do not become mid before low vowels. Using simply the STAY and RESIST constraints, this is easily demonstrated, as shown for vowels in the tableaux in (26). Either STAY HIGH is dominated (and so STAY LOW and RESIST LOW are too) or STAY HIGH is undominated, and high vowels resist assimilation altogether. The two possible rankings are given in (26)

(26) Reverse attraction impossible with STAY and RESIST

a. STAY HIGH dominates assimilation constraints → no assimilation

/…i…a…/	STAY HIGH	IDENTICAL	RESIST MID	RESIST LOW
√ … i…a…		*		
…e…a…	*!	*	*	
…a…a…	*!			*

b. Assimilation over STAY HIGH → full assimilation

/…i…a…/	IDENTICAL	STAY HIGH	RESIST MID	RESIST LOW
… i…a…	*!			
…e…a…	*!	*	*	
√ …a…a…		*		*

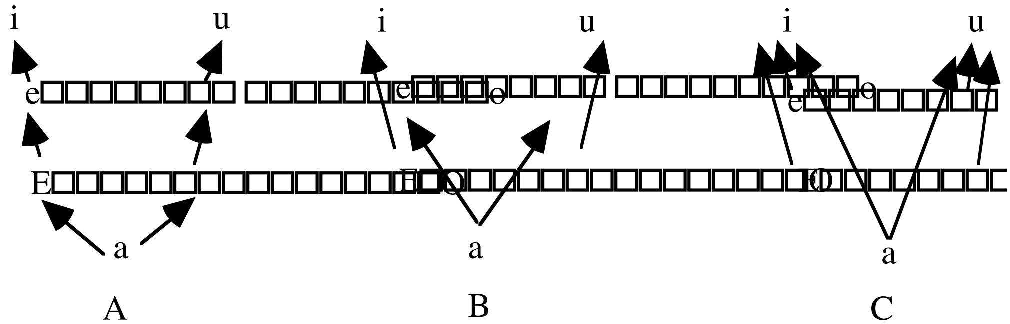
As the tableaux in (26) show, STAY- and RESIST- driven attraction is impossible going *down* the scale (from HIGH toward LOW or from IV3 toward IV1). Unfortunately, the STAY and RESIST constraints are not the only source of attraction. Attraction occurs also in chain shift, which is constrained by IDENT-ADJ [X]. Because of IDENT-ADJ [X], sometimes full assimilation can not occur. In such cases chain shift should occur if ADJACENT is appropriately ranked. The question is thus why we get LOW → MID → HIGH chain shifts without HIGH → MID → LOW chain shifts. Similarly, why do we get voiceless → voiced → sonorant chain shifts without sonorant → voiced → voiceless chain shifts? Stepwise vowel raising occurs without stepwise lowering, while eclipsis occurs without reverse eclipsis. Lenition, however, is paired with an occasional fortition.

Although lowering chain shifts do not occur, the coalescence of low and high vowels to mid vowels in languages like Sanskrit (discussed in 3.4.1) do indicate that the high vowels are sensitive to the relative faithfulness constraints that should occasionally produce chain shifting lowering. Evidently the top of the scale (IV3 or HIGH) exerts some attractive force that is not yet properly understood or modeled. This is obviously related to the general question of what makes certain segments exert an assimilating influence over others, a question beyond the scope of this dissertation.

Another issue that remains unresolved is that of the precise number of possible vowel heights. I have used a ternary scale to model vowel height. A ternary height scale, with the addition of [ATR] is some cases, is sufficient for many languages. In other languages, however, additional heights appear to be called for, as argued by Clements (1991a). For instance, in Nzɛbi a chain shift raising occurs over four heights: a → ɛ → e → i and ɔ → o → u . This is triggered by a suffix vowel /-i/ (Clements 1991a, Guthrie 1968). A chain shift like the Nzɛbi one does not naturally succumb to an analysis in terms of three vowel heights and [ATR], as Clements points out.

Assuming that more than three vowel heights are sometimes required, can the VH scale be expanded to handle such cases? In some senses, the answer is yes. The ternary scales model in some ways handles extra vowel heights better than other models. According to Parkinson (1995), height harmonies in which vowels raise two steps (without fully assimilating) are unknown. The present model explains this fact neatly. The constraint that keeps output values close to their inputs in a chain shift is the IDENT-ADJ [VH] constraint. IDENT-ADJ [VH] is satisfied by a move of one step on the scale, but violated by more than one. If the scale had four values, IDENT-ADJ [VH] would be equally violated by a move of two or a move of three. Therefore, a segment obeying IDENT-ADJ [VH] would move only one step, while a segment violating IDENT-ADJ [VH] would be free to assimilate fully. The situation is illustrated in (27).

(27)



In (27A), the vowels each raise by one height. Here IDENT-ADJ [VH] is obeyed, though IDENTICAL is violated. In (B), the vowels raise by two steps. Here IDENT-ADJ [VH] and IDENTICAL are both violated. In (C) the vowels all become high, violating IDENT-ADJ [VH] but satisfying IDENTICAL. The case in (B) is predicted not to occur. There is no reason to violate IDENT-ADJ [VH] if it is not to satisfy the assimilation constraint. This is a good result, since cases like (B) indeed do not occur.

The ternary scales model does not translate perfectly to extra vowel heights, however. In the absence of full assimilation (as in (27C), chain shift occurs, as in (27A). On a ternary scale it can be said that an attracting segment satisfies ADJACENT, even though it violates IDENTICAL. In (27A), however, the underlying /a/ does not satisfy ADJACENT either, and yet it is attracted toward the high vowels.

We have, then, an interesting puzzle. The behavior of extra-ternary vowel systems confirms the formulation of the relative faithfulness constraints, which distinguish between adjacent and non-adjacent movements, making vital use of the adjacency relation. On the other hand, the behavior of these extra-ternary vowels systems appears to contradict the formulation of the assimilation constraints as particularly sensitive to the adjacency relation. The raising in languages such as Nzɛbi does not always result in values which are adjacent to the assimilation trigger. The vowel height approaches the triggering value without necessarily becoming adjacent to it. It appears that ADJACENT would have to be reformulated, unless other solutions for the extra-ternary chain shifts emerge.

In summary, this section has examined certain issues that would need to be resolved prior to a full implementation of the VH scale. First, there is the fact that chain shift only occurs in an upward direction. This fact is reflected also in the IV scale, and to a lesser extent in the CS scale. The attractive force of the high end of the scale is yet to be explained.

Secondly, this section has considered the possibility of expanding the vowel height scale to contain additional height values. The IDENT-ADJ [VH] constraint provides an easy answer to the reason why stepwise raising never proceeds by two height steps at a time. IDENT-ADJ [VH] is violated by any movement greater than one. If IDENT-ADJ [VH] is to be violated, then it must be through the force of a dominating IDENTICAL, which demands full assimilation, not stepwise assimilation. Not so easy is the case of the ADJACENT constraint. In a ternary scale ADJACENT is active in attraction and chain shift. In an extra-ternary chain shift, however, ADJACENT is not satisfied by the first link(s) in the chain. I leave open the issue of whether ADJACENT should be reformulated based on the available evidence from extra-ternary vowel systems. I return to the assumption of a ternary VH scale for the remainder of this chapter.

5.5. Markedness on the CS and VH Scales

In Chapter 4 it was argued that the middle value on a ternary scale is the most marked, since it is the value that complicates the system from a maximal binary distinction. This section explores the consequences of applying this principle to the CS and VH scales.

5.5.1 CS2 Markedness: Sui, Korean

On the CS scale, the CS2 value should be the most marked. This means that fricatives should be more marked than stops or vowels. (I leave aside liquids, since laterals may be stops (CS1) and rhotics may be approximants (CS3) in some languages.) In the Australian languages this prediction appears to be well borne out. Most Australian languages have no fricatives (Dixon 1980). World wide, the case is not so clear, however. According to the UPSID database (Maddieson 1984), all languages have stops, and all languages have vowels, while the great majority of languages also have at least one fricative. Of the UPSID languages, 93.4% (296) have at least one fricative. Of the remaining 21 languages, 15 are Australian. The lower percentage of languages with fricatives is made more significant, however, by the fact that languages tend to have more stops than fricatives. 63% of the UPSID languages have 5 to 11 stops and affricates, with the minimum number being 3. 58% of languages have 1 to 4 fricatives. It appears, then, that fricatives are more marked than stops and vowels, since they appear in fewer languages and in fewer numbers in the languages they do appear in. The parallel between markedness of IV2 and that of CS2 is brought out by Maddieson (1984): 'There is a tendency for smaller inventories to have no voicing contrast in stops and to lack fricatives apart from some kind of /s/.' (p.11).

I conclude, then, that CS2 is indeed the most marked value on the CS scale, non-contextually. There is therefore a non-contextual *CS2 constraint. The persistence of *s* when other fricatives are prohibited may well be due to extra faithfulness constraints on [strident]. In 5.3.1 above, I suggested that in Irish the lenition of *t* to *s* is blocked by a high-ranking RESIST [strident]. If [strident] is subject to its own faithfulness constraints, then there will be cases where other fricatives are ruled out by a general *CS2 constraint, but the *s* will remain due to a high-ranking STAY [strident]. The elimination of non-strident fricatives from an inventory is shown in (28a), while the retention of *s* is shown in (28b).

(28) Action of *CS2

a. Non-stridents eliminated

/…f…/	STAY [strident]	*CS2	STAY CS2
f		*!	
√ p			*

b. Strident *s* is retained

/…s…/	STAY [strident]	*CS2	STAY CS2
√ s		*	
t	*!		*

The domination of STAY CS2 by *CS2 in (29a) means that the non-strident fricative is lost. The domination of *CS2 by STAY [strident], however, means that a strident /s/ is retained in (28b).

The markedness of CS2 should have other effects as well as the exclusion of non-strident fricatives (and sometimes all fricatives) from inventories. As discussed in Chapter 4, the markedness of IV2 had effects on epenthesis and neutralization too. The *CS2 constraint works in these areas too. For instance, I know of no languages that use an epenthetic fricative. The epenthesizing languages discussed in Chapter 4, for example, use a CS1 stop (Axininca Campa) and a CS3 rhotic glide (Eastern Massachusetts English).

The *CS2 constraint is also at work in coda neutralization. This would result from a ranking of *CS2 between STAY CS2-onset and STAY CS2. An example of the effects of *CS2 in such a ranking comes from the Sui language, spoken in southeastern China. A syllable in Sui may begin with any of the following consonants (Li 1948).

(29) Initial Consonants in Sui

	stops	nasals	continuants
labials	p p' b ʔb	m ʔm m̥	f w ʔw
dentals	t t' d ʔd	n ʔn n̥	
lateral			l
sibilants	ts ts'		s z
prepalatals	tš tš '	ň ʔň ň̥	š j ʔj
velars	k k'	ŋ ʔŋ ŋ̊	x ɣ ʔɣ
uvulars	q q'		R
laryngeals		ʔ	h

Of these 43 consonants, only *m*, *n*, ŋ, *p*, *t*, *k* may occur syllable-finally. In other words, only IV1 or IV3 and CS1 segments may occur in codas. Evidently a number of neutralizations are going on. Li gives no examples of alternations, since all syllables are consonant-initial, and so a particular segment can not alternate between syllable-final and syllable-initial. However, in an OT framework the ranking of the constraints must neutralize the illicit consonants in coda position, since they can not be ruled out at the input.

Among the neutralizations that occur is voicing. IV2 is ruled out, as in German in Chapter 4.5. Glottalization and aspiration (on sonorants, at least, assuming that voiceless sonorants are actually aspirated) are also ruled out. The uvulars are missing, as are the laryngeals. The glides presumably do not occur because they are vocalic in moraic positions—a number of syllables with diphthongs are listed. The remaining neutralization is of the affricates, fricatives and liquids, i.e. segments with CS2. The neutralization of CS2 is brought about by the ranking of *CS2 above STAY CS2 (but below STAY CS2-onset, so that CS2 segments are retained in onsets). This is shown in (30). The tableau in (30) parallels (17a) for German IV neutralization in 3.5. STAY CS2-onset is left out, because it is irrelevant to the coda consonant under consideration.

(30) CS2 neutralization in Sui

…f.	*CS2	STAY CS2	RESIST CS1
…f.	*!		
√ …p.		*	*

The *CS2-CODA constraint forces neutralization of fricatives and liquids in Sui. As indicated in (30), an input fricative that undergoes neutralization is predicted to become a stop, since RESIST CS1 is the lowest ranked RESIST constraint on the CS scale.

The derivation of stops from fricatives by neutralization is confirmed by Korean. In Korean, coronal fricatives and affricates appear as *t* in codas (there are no fricatives or affricates at other places of articulation). Examples are given in (31) (from Jun 1993). The words are given phonemically, with the output value of the final consonant listed in the next column.

(31) Korean CS2 neutralization

č ʰač	t	'search for'
seuč əs	t	'pickled shrimp'
os	t	'cloth'
č aŋmik'oč ʰ	t	'rose'
mjəč ʰ	t	'what'

As in Sui, the fricatives and affricates do not appear in coda position. Due to alternations, however, we can tell that their place is taken by stops. This is as predicted, given the low ranking of RESIST CS1 compared to the other alternative, RESIST CS3.

The Sui and Korean cases bring up another point. Both Sui and Korean display a number of neutralizations. In Sui voicing, aspiration and glottalization neutralize as well as CS2, while in Korean aspiration and glottalization also neutralize. Such clustering of neutralization is used by Clements (1985), McCarthy (1988) and Lombardi (1991) to argue for a single Laryngeal node which dominates features of voicing, aspiration and glottalization. The fact that all three of these features can neutralize at the same time was used as evidence that voicing, aspiration, and glottalization are separated from the rest of the feature geometry by their own superordinate Laryngeal node. In the present work, voicing has been referred to continually, but without the supposition of a Laryngeal node. If voicing is part of a ternary scale, what about the other laryngeal features? I argue that the clumping of laryngeal features under a single node is not a conclusion required by the available evidence. In languages such as Sui and Korean, where a great deal of neutralization takes place, fricatives also neutralize.

The clustering of laryngeal neutralization with stricture neutralization is not confined to Sui and Korean. Thai, for example, is a language cited by Clements (1985), McCarthy (1988) and Lombardi (1991) as showing the laryngeal features acting together. Thai (Intrakomhaeng 1969) has a three-way contrast between plain voiceless, voiceless aspirated, and plain voiced consonants in initial position. Finally the voiceless aspirated and voiced series are ruled out. Initially, the fricatives *f*, and *s* and the liquids *r* and *l* occur. Finally, these CS 2 consonants are excluded. Similarly, in Gbɛ́ yá (Samarin 1966), voiced obstruents, glottalized consonants, fricatives (*f*,*s*,*v*,*z*), labio-velars, and prenasalized stops are permitted initially but not finally (the liquids *r* and *l* —which may be CS2—are allowed, however).

The neutralization of fricatives in codas has never led to the proposal of a node dominating [voice], aspiration, glottalization and [continuant]. Since fricatives are considered as neutralizing independently of a laryngeal node, there is no reason why voiced obstruents may not do so as well. If codas have by definition lower faithfulness requirements (or higher markedness constraints), neutralization on a number of dimensions is to be expected, regardless of the feature geometry. In the examples given here, prenasalized stops and labio-velars (Gbɛ́ yá), and uvulars (Sui) are also neutralized in codas, independantly of voicing, glottalization, aspiration and stricture neutralizations.

In summary, CS2 can be seen as the marked value of the CS scale, just as IV2 is the marked value of the IV scale. This leads to a number of results: inventories without fricatives, inventories with *s* as the only fricative, epenthesis of stops and glides but not fricatives, and neutralization of CS2 in syllable codas. The fact that CS2 neutralizes in the same environment as IV2 casts doubt on the hypothesis that voicing, aspiration and glottalization are grouped together under a single node because they all undergo coda neutralization.

5.5.2 VH-MID Markedness: Nancowry, Russian

Applying the middle-as-marked hypothesis to the ternary VH scale yields the prediction that mid vowels are the non-contextually marked vowels. In many respects this prediction is borne out.[6] In the UPSID database, mid vowels do not occur without both high and low vowels (Maddieson 1984). Only two out of the 317 languages are exceptions to this rule, as they reportedly lack low

[6] See Beckman (1995, 1996) for applications of mid vowel markedness in a non-scalar framework.

vowels. A *VH-MID constraint to parallel the *IV2 and *CS2 constraints appears in order.

A possible initial objection is the following. Although mid vowels appear in a smaller number of languages, the actual frequency of mid vowels present in the database outnumbers that of high vowels 40.5% to 39.0%, and the low vowels by 40.5% to 20.5%. In other words, if a language has mid vowels at all, it may very well have more mid vowels than high vowels or low vowels. This is presumably because the unmarked VH value for [ATR] contrasts is the mid height, even though mid may itself be marked. Additionally, low vowels resist contrasts in backness and roundness, giving mid vowels a numerical advantage.

If VH-MID is the marked value, we expect to see neutralization processes similar to those occurring on the CS and IV scales. The parallel to coda neutralization for vowels is unstressed syllable neutralization.[7] In unstressed syllables mid vowels should be lost and high and low vowels remain. This is just the case in Nancowry (Radhakrishnan 1981). In stressed syllables the following vowels may occur.

(32) Nancowry vowels in stressed syllables

i	ɯ	u
e		o
ɛ	ə	ɔ
æ	a	

In unstressed syllables, however, the vowel inventory is reduced to only three: *i, u, a*.[8] The mid vowels are eliminated, as well as the marked ɯ and *æ*. Just as *IV2 was more effective in codas because codas do not have the additional STAY 2-onset constraint, so *VH-MID is more effective in unstressed syllables

[7] There can also be neutralization in non-initial syllables, due to the prominence (and therefore higher faithfulness) of initial syllables (Beckman 1995, 1996).
[8] An exception is word-finally, where *i* is centralized to *e* and *a* is centralized to ə.

because the more prominent stressed syllables have an additional STAY MID-stressed constraint.[9] This application of positional faithfulness to the prosodic realm follows Alderete (1995), who assigns prosodic heads higher faithfulness than other elements. In (33) the *VH-MID constraint rules out unstressed mid vowels but not stressed mid vowels.

(33) Behavior of *VH-MID-UNSTRESSED in Nancowry

a. Unstressed mid vowels are ruled out.

/…e…/	STAY MID-stressed	*VH-MID	STAY MID
e		*!	
√ a			*

b. Stressed mid vowels remain

/…é…/	STAY MID-stressed	*VH-MID	STAY MID
√ é		*	
á	*!		*

In tableau (33) the *VH-MID constraint having an effect in less prominent positions perfectly parallels the *IV2 constraint causing neutralization in codas. In positions of neutralization (unstressed syllables for vowels, syllable codas for consonants), the middle value of the scale is disallowed, even when it is allowed elsewhere in the language. This is because additional faithfulness requirements on the prominent positions allow these positions to escape neutralization. In vowels, the neutralization effect is achieved by ranking the *VH-MID constraint between the specific faithfulness constraint STAY MID-stressed and the general faithfulness constraint STAY MID.

[9] Just as coda neutralization can be attributed to either lower coda faithfulness or extra coda markedness, so unstressed syllable neutralization may be due to either extra markedness or lower faithfulness.

In the tableau above I assume that the neutralized vowel will surface as *a*. This is in keeping with the proposed VH faithfulness hierarchy in (18) above, by which low vowels receive lowest faithfulness. Alternations confirming this prediction occur in Russian, as shown in (34). When the mid vowel is stressed, it is allowed to surface, but when it is unstressed, it is replaced by a low vowel.

(34) Russian mid vowel neutralization (Kenstowicz & Kisseberth 1979)

glaž -ú	1st singular 'gnaw'	singular	plural	
glóž -iš	2nd sing	stól	stal-ý	Nom, Acc 'table'
glóž -it	3rd sing	stal-á	stal-óf	Genitive
glóž -im	1st plural	stal-ú	stal-ám	Dative
glóž -it'i	2nd plural	stal-óm	stal-ámi	Instrumental
glóž -ut	3rd plural	stal'-é	stal-áx	Locative

As (34) shows, an unstressed mid vowel becomes low (except after a palatal(ized) consonant—an environment which requires high vowels). The Russian vowel neutralization is illustrated by the tableau in (33), already given for Nancowry.

At this point the obvious question is that of neutralization to schwa. In a language such as English unstressed vowels reduce to schwa, not to peripheral vowels. I propose that the English schwa has no phonological height, as evidenced by its highly variable phonetic realization. The reduction to schwa is therefore the elimination of *all* height contrasts, not just the most marked one(s).

It can be said, then, that the VH scale parallels the IV scale in its treatment of markedness, as well as in assimilation and faithfulness. The middle value of the scale is the most marked, non-contextually. Contextually, such as in the presence of [ATR] contrasts, it may be relatively unmarked. The markedness of mid vowels leads to languages without mid vowels in their inventories. Further, it leads to neutralization in languages that allow mid vowels in stressed syllables but not in unstressed syllables.

A further prediction of the *VH-MID constraint is that mid vowels should not be epenthetic. This is problematic. Mid vowels do occur as epenthetic vowels in some languages. For example, *s* plus stop clusters in Latin took on a preceding epenthetic *e* in Spanish and French, so that Latin *spē rā re* 'to hope (for)' became *esperar* in Spanish and *espérer* in French. Why the epenthesis behavior of the VH scale runs counter to the evidence from vowel inventories and from neutralization remains to be determined.

5.6 Constructing the Sonority Hierarchy from Ternary Scales[10]

The three ternary scales presented in this dissertation—Inherent Voicing, Consonantal Stricture and Vowel Height—can be combined to form a larger scale, that of the Sonority Hierarchy. Based on syllabification processes in Berber, which exhibits fine distinctions in sonority (Dell & Elmedlaoui 1985), the following can be said to be the Sonority Hierarchy.[11]

(35) The Sonority Hierarchy
voiceless stops
voiced stops
voiceless fricatives
voiced fricatives
nasals
liquids
high vocoids
mid vowels
low vowels

While the Sonority Hierarchy is apparently viewed by syllabification processes as a single scale, other phonological processes seem not to refer to such a single entity. Scalar processes such as lenition and eclipsis do not operate on

[10] An earlier version of some of this material was presented at the LSA as Gnanadesikan 1995a.
[11] For use of the Sonority Hierarchy see Sievers 1881, Jespersen 1904, de Saussure 1916, Zwicky 1972, Hankamer & Aissen 1974, Hooper 1976, Foley 1977, Steriade 1982, Selkirk 1984, Zec 1988, Clements 1990, Prince & Smolensky 1993.

the Sonority Hierarchy (see 5.3.2 above for reasons why lenition does not operate on sonority). The conclusion is that the Sonority Hierarchy is composed of smaller pieces. These pieces, I claim, are the IV, CS and VH scales.

If the ternary scales are each arranged according to their inherent sonority or prominence, we get the following prominence hierarchies.

(36) Scalar Prominence
IV3 > IV2 > IV1
CS3 > CS2 > CS1
VH-HIGH > VH-MID > VH-LOW

To derive the Sonority Hierarchy, these scales must be combined in a type of harmonic alignment similar to that Prince & Smolensky (1993). The matter is kept from excessive complication by the fact that the VH values only occur with CS3 and IV3. Only IV and CS values can combine freely. The combination proceeds much like the process of captains choosing teammates in sports. Assume that the CS scale dominates the IV scale. This means that the CS scale has the first turn. The first element of CS combines with the IV values. The sequence therefore begins $\begin{bmatrix}\text{CS3}\\\text{IV3}\end{bmatrix}$, $\begin{bmatrix}\text{CS3}\\\text{IV2}\end{bmatrix}$, $\begin{bmatrix}\text{CS3}\\\text{IV1}\end{bmatrix}$. CS3 is now finished with. The next element to combine is the first element of the other scale, IV3.[12] IV3 can not combine with CS3, since that value is finished. It goes on to combine with CS2 and CS1. The sequence therefore continues $\begin{bmatrix}\text{CS2}\\\text{IV3}\end{bmatrix}$, $\begin{bmatrix}\text{CS1}\\\text{IV3}\end{bmatrix}$. IV3 is then out of options. The combination returns to the first scale. CS2 combines with IV2 and IV1, yielding $\begin{bmatrix}\text{CS2}\\\text{IV2}\end{bmatrix}$, $\begin{bmatrix}\text{CS2}\\\text{IV1}\end{bmatrix}$. Next goes IV2, which can only combine with CS1, giving $\begin{bmatrix}\text{CS1}\\\text{IV2}\end{bmatrix}$. CS1 then combines with IV1 for $\begin{bmatrix}\text{CS1}\\\text{IV1}\end{bmatrix}$. There are then none left for IV1 to combine with, and the process is ended.

[12] This is where the method of harmonic alignment diverges from Prince & Smolensky's method. In Prince & Smolensky's harmonic alignment each value of the dominant scale combines with those of the other, rather than the scales alternating turns. The results of the two different methods only differ if each scale has more than two members.

If the sequence is put together and the vowel height values added to the $\begin{bmatrix}\text{CS3}\\ \text{IV3}\end{bmatrix}$ specification, the resulting hierarchy is that in (37).

(37) Sonority Hierarchy given by Ternary Scales.[13]

$\begin{bmatrix}\text{CS3}\\ \text{IV3}\\ \text{VHlo}\end{bmatrix}$	$\begin{bmatrix}\text{CS3}\\ \text{IV3}\\ \text{VHmid}\end{bmatrix}$	$\begin{bmatrix}\text{CS3}\\ \text{IV3}\\ \text{VHhi}\end{bmatrix}$	$\begin{bmatrix}\text{CS3}\\ \text{IV2}\end{bmatrix}$	$\begin{bmatrix}\text{CS3}\\ \text{IV1}\end{bmatrix}$	$\begin{bmatrix}\text{CS2}\\ \text{IV3}\end{bmatrix}$	$\begin{bmatrix}\text{CS1}\\ \text{IV3}\end{bmatrix}$	$\begin{bmatrix}\text{CS2}\\ \text{IV2}\end{bmatrix}$	$\begin{bmatrix}\text{CS2}\\ \text{IV1}\end{bmatrix}$	$\begin{bmatrix}\text{CS1}\\ \text{IV2}\end{bmatrix}$	$\begin{bmatrix}\text{CS1}\\ \text{IV1}\end{bmatrix}$
a	e,o	i,u	ɦ	ʔ,h	r	m,n	v,z	f,s	b,d	p,t

The Sonority Hierarchy is thus a combination of three ternary scales which are independently motivated. The syllabification constraints then make use of the combination.

5.7 Other Possible Scales

In the course of this dissertation three ternary scales have been proposed, and have been used to account for a number of previously opaque phonological processes, notwithstanding some unresolved issues mentioned in this chapter. The ternary IV, CS and VH scales replace the conventional binary or privative [voice], [sonorant], [continuant], [consonantal], [high] and [low]. It is therefore tempting to ask whether there are other ternary scales.

Two possibilities present themselves. The first is suggested by the fact that there are three kinds of sonorants consonants: nasals, laterals, and rhotics. The fact that these three segment types form a class is recognized by Rice & Avery (1989), who group them under an SV node. The sonorant consonants have special affinities for one another, as demonstrated by assimilations in English Latinate prefixes: *inadequate*, *illegal*, *irreparable*. The nasals can be recognized as the default member of the class, hence Rice & Avery make them the unspecified SV consonants. On the other hand, the default status of the nasals could also

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[13] I have assigned *h*, ɦ and ʔ positions on the hierarchy based on their scale values. These laryngeal consonants, while evidently quite sonorous in some languages, have other factors which constrain their positions in syllables, so it is difficult to confirm their position in the hierarchy.

theoretically derive from being at the lower end of a ternary scale and being associated with the lowest ranked faithfulness constraints.

If this scale does exist, however, it operates on different principles than the scales analyzed in this dissertation. For one thing, attraction does not occur between the sonorant consonants. To my knowledge there is no such thing as a nasal becoming lateral in the environment of a rhotic, or anything similar.

Another possible scale has similar properties. It is suggestive that there are three major oral places. One could therefore propose a scale consisting of Coronal, Dorsal, Labial. These three features obviously form a ternary class. One of them, Coronal, has default status, that could again be attributed to holding the lowest place on the scale. The same problem arises, however, as with the sonorant consonants. There is no scalar behavior in the move from one place to another. Attraction and chain shift do not occur. There is no such process as coronal becoming dorsal before labial, or anything similar.

While the place and sonorant consonant triads remain suggestive, they can not be said to operate on the same principles as other ternary scales, even if they are scalar. The possibility of integrating these triads with the ternary scales into a larger ternary framework remains highly speculative.

5.8 Conclusions

This dissertation has presented a theory of ternary scales which are designed to replace many of the traditional binary or privative features. In Chapters 2, 3 and 4 the scalar framework was explored with application to the Inherent Voicing Scale, while the present chapter applied the framework to the Consonantal Stricture and Vowel Height scales.

The ternary scales framework has been inspired by a number of phonological patterns that traditional binary or privative feature theories fail to capture. In the ternary scales framework, chain shifts can be analyzed as a single coherent process. Both attracting and non-attracting assimilations can be derived. Underspecification of features such as [voice] in sonorants can be done away with, as there is no longer any need for a 'fill-in' of features partway through a derivation. Privativity of [voice], with its attendant apparatus of fusion and final exceptionality, is also no longer required. Neutralization of voiced obstruents, fricatives, and mid vowels is given a unified treatment. The scales can furthermore be combined to create the Sonority Hierarchy.

The introduction of scales into the phonological toolbox allows certain new but necessary formulations. Since a scale is made up of certain entities in a fixed ordered relationship, the phonology can now refer to not just the phonological entities (i.e. features), but also to the relationship between them. Thus the values on a scale each take their place in fixed faithfulness hierarchies. Which scale value neighbors which is also referred to by the phonology. Because the relation of scale adjacency is now part of the phonology, the relative faithfulness constraints are sensitive to the difference between one move on the scale (to an adjacent value) and two moves (to a non-adjacent value). A move of two on the scale is not simply double the faithfulness violation that one move is. Rather it is a different and a worse kind of violation, since non-neighboring values are do not participate in the relationship of adjacency. The relations between scale values are also referred to by assimilation constraints, which demand identity of scale value between assimilation trigger and target, but which demand adjacency of scale value as a second best. While certain aspects of the theory remain to be worked out, the introduction of scalar assimilation, markedness and faithfulness furthers the descriptive power of generative phonology in a number of useful ways.

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