Geminates, The OCP and The Nature of Con

by

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ABSTRACT OF THE DISSERTATION

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This dissertation is concerned with the Obligatory Contour Principle (OCP) and its relationship to the representation of geminate consonants. The OCP blocks lexical forms with pair geminates, a pair of adjacent identical melodies. Therefore geminates must be represented as single melodies associated to two timing units. The OCP is also active on outputs, blocking phonology from creating pair geminates. The dual nature of the OCP (as both input and output constraint) is derived from the interaction of ranked and violable *output* constraints in an Optimality-theoretic grammar. In this analysis, no input restrictions are required.

The OCP is interpreted as a constraint on the set of constraints in UG (CON). The lexical OCP is accounted for by positing that no faithfulness constraint requires maintaining a distinction between one segment and two identical adjacent segments. The output OCP is accounted for by positing that output markedness constraints universally prefer one segment to two. The interaction of these markedness and faithfulness constraints neutralizes the contrast between pair and single geminates. One consequence of the analysis is that no specific OCP constraint is required. Rather, the effects of the OCP follow from general markedness considerations.

Geminates behave differently with respect to phonological changes compared to their singleton counterparts. Geminates are sometimes affected by changes that affect singletons (alterability). Examples of geminate alterability are found in Faroese, Persian, Fula, and Alabama. The fission of geminates appears to be a counter example to the claim that markedness

universally prefers one segment to two. It is shown that fission follows from the activity of faithfulness constraints relativized to the syllable onset. The analysis of fission captures an asymmetry in fission processes. No fission process creates a cluster where the initial segment is more faithful to the input than second segment.

In addition to alterability, geminates are sometimes unaffected by changes that affect singletons (inalterability). Examples of geminate inalterability include Tiberian Hebrew, Latin, and the restriction of coda consonants in many languages. Universal inalterability must be an effect of the constraint responsible for the change in singletons. Parochial inalterability however, is the result of standard constraint interaction in an OT grammar.

PREFACE

This version differs slightly from the deposit version. Several typos were corrected. In addition the formatting has been changed to facilitate two-up printing. These formatting changes have affected the pagination of the document so that the pagination differs from that of the deposit version.

Edward Keer
October, 1999

DEDICATION

To my wife Kristine, for all her love and support.

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> By degrees I made a discovery of still greater moment. I found that these people possessed a method of communicating their experience and feelings to one another by articulate sounds. I perceived that the words they spoke sometimes, produced pleasure or pain, smiles or sadness, in the minds and countenances of the hearers. This was indeed a godlike science, and I ardently desired to become acquainted with it.
>
> *Frankenstein*
> Mary Shelley

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1. Introduction

The hypothesis that phonology is driven by constraints on representation raises the question of what phonological constraints in Universal Grammar are possible. This question is particularly relevant in Optimality Theory (Prince & Smolensky 1993) where constraints play a central role. In this dissertation I will argue for a specific model of the constraints in Universal Grammar based on the typology of geminate behavior in phonological processes.

An Optimality-theoretic grammar has the structure given in (1).

(1) *Structure of an Optimality-theoretic grammar* (Prince & Smolensky 1993: 4)

a. GEN (In$_k$) → {Out$_1$, Out$_2$, …}

b. EVAL (Out$_i$, 1 i ∞) → Out$_{real}$

The grammar consists of two functions, GEN and EVAL. The function GEN generates a set of output candidates from a given input. The function EVAL evaluates the set of output candidates and gives the real output. The set of output candidates are evaluated against a universal set of constraints (CON). The constraints are ranked on a language particular basis. The output candidate of a particular ranking is that candidate which best satisfies the constraint hierarchy.

Much of the work in Optimality Theory argues from empirical grounds for a specific constraint or constraint type in CON. For example, we observe cross-linguistically that syllable codas are marked. That is, they are sometimes banned altogether from a language, and in languages that allow codas they are generally avoided.[1] Therefore we can posit the existence of a constraint NOCODA as in (2).

[1] No language parses the sequence *cvcv* as *.cvc.v.* (Prince & Smolensky 1993: 86).

(2) NoCoda (Itô 1986, Prince & Smolensky 1993)

Syllables do not have codas.

Here we have argued from the typology of syllable types for the existence of a specific constraint in Con. These types of arguments can be extended to cover sets of constraints based on their interaction (see the discussion of syllable typology in Prince & Smolensky chapter 7).

There have also been more general theories of Con argued for on theoretical grounds. One example is the view that phonological (markedness) constraints must be grounded in phonetics (Steriade 1993b, Archangeli & Pulleyblank 1994, Jun 1995, Flemming 1995, Kaun 1995, etc.). This hypothesis states that the set of universal phonological constraints is directly derived from phonetic considerations. Another approach, advocated by Prince (1997) states that based on the architecture of Optimality Theory we can make some strong claims about what constraints in Con must look like. For example Prince argues that there can be no 'except when' constraints such as in (3)

(3) NoCoda/word internal

syllables do not have codas, except when word-final.

The 'except when' structure of this constraint mirrors the effect of constraint interaction, a crucial part of the theory. For example the observation that syllables are coda-less except word finally in a language can be handled with three constraints which are ranked crucially. First, the general constraint NoCoda must dominate some faithfulness constraint resulting in the general lack of syllable codas in the language. Second, some constraint which prefers codas word-finally outranks NoCoda, thus forcing violation of this markedness constraint at the word edge. The 'except when' character of coda distribution results from the interaction of general constraints. Therefore 'except when' effects need not and should not be incorporated into specific constraints.

The goal of this dissertation is to argue from empirical grounds for general constraints on Con. Specifically, this dissertation is concerned with behavior of geminate consonants and what that behavior can tell us about the nature of the phonological constraints in Universal Grammar.

A geminate consonant is a consonant that is of a longer duration than non-geminate consonants. The example in (4) from Swedish shows that in some languages the length of consonants is distinctive.

(4) *Swedish*

kapa 'to cut away/off' kappa 'coat, cloak'

In languages like Swedish which have a short/long distinction for consonants, the geminate consonant is typically from one half to one and half times the duration of the shorter segment. I will refer to long consonants as geminates and short consonants as singletons.

The behavior of geminates may be different from the behavior of single segments with respect to phonological alternations within a language. In (5) I show the three ways in which a geminate can act in an environment where singleton segments change as well as an example language for each.

(5) *Geminates in environments where singletons change*

Geminate Result	**Example**
a. Inalterability	***Tiberian Hebrew*** Stops spirantize post-vocalically. Geminate stops fail to spirantize post-vocalically.
b. Fission	***Alabama*** Voiced stops nasalize in codas. Voiced geminates split into nasal + voiced stop sequences.

c. Full Alterability	***Faroese*** Singleton segments palatalize before front high and mid vowels. Geminate segments also palatalize in the same environment

The most notable situation is geminate inalterability (Leben 1980, Guerssel 1977,1978, Kenstowicz 1970, Pyle 1970). Geminate segments often fail to undergo some alternation that their singleton counterparts undergo in the same environment. Geminate Fission (Selkirk 1990) is when a geminate segment is turned into two distinct segments, one of which has been altered and one has not. Finally, full alterability is when the entire geminate undergoes the change. In this case there is no discrepancy between singleton segments and geminates.

Research on geminate behavior has revealed three universals. First, lenition processes (weakenings, including spirantization and voicing) universally result in inalterability for geminates (Churma 1988, Kirchner 1998a,b). Second, it has been shown that onset specific processes (hardenings and restrictions on types of onsets) universally result in alterability (Churma 1988, Inkelas & Cho 1993). Finally, I will show that processes whose environment is to the right of a geminate never produce fission. That is, fission always creates a sequence of two segments, XY, where the left segment has changed and the right segment has not.

Previously, two mutually supportive answers have been given to the question of why geminates may behave differently than singletons. First is the nature of the phonological representation of geminates (Leben 1980, McCarthy 1986). Second is the interaction between phonological representations and rules (Schein & Steriade 1986, Hayes 1986, Inkelas & Cho 1993). In short, geminates are different because they are represented differently phonologically and because phonological processes are sensitive to this representational difference.

Optimality Theory provides new insight to the behavior of geminates. I propose a specific theory of the constraint set CON in UG which builds on both of the insights above. However this theory also sufficiently restricts the conditions under which geminates are inalterable, fission or are totally alterable. The proposal rests on the assumption that geminates are single melodies associated to two timing units (Leben 1980, McCarthy 1986). I derive this restriction from output constraints. Furthermore, I assume that the trigger for geminate fission is faithfulness to the onset. This proposal captures the asymmetry found with geminate fission processes.

In sections 1 and 2 of this chapter I will outline background assumptions to the dissertation. In section 1 I outline the correspondence theory of faithfulness and positional faithfulness. In section 2 I discuss the moraic theory of geminates. In section 3 I provide a framework for how inalterability and alterability must be captured in Optimality Theory. Finally, section 4 outlines the rest of the dissertation.

1.1 Correspondence Theory of Faithfulness

I will be adopting the Correspondence Theory of Faithfulness (McCarthy & Prince 1995) along with Positional Faithfulness as proposed by Beckman (1997). Correspondence Theory allows input-output mappings where two segments stand for one segment. These multiple relations can go from input to output or vice versa. Either one input segment becomes two output segments or two output segments are derived from one input segment. Both of these mappings will be crucial to understanding the typology of geminate behavior outlined in (5) above. Positional Faithfulness theory asserts that in addition to general faithfulness constraints there are also faithfulness constraints that are relativized to prosodic positions. I argue in chapter three that geminate fission is a positional faithfulness effect.

Under correspondence theory, GEN emits a set of candidates. Each candidate includes the input which is expressed as a set segments, an output which is also expressed as a set of segments and a relation (ℜ) between the elements of the input and output. This is shown schematically in (6).

(6) *GEN*

GEN(i) = {(i, o_1, $\mathfrak{R}_1$), (i, o_2, $\mathfrak{R}_2$), …}

Again, the input and output sets are sets of segments. The correspondence relation holds between the segments in the two sets. For example GEN(*pakta*) gives the following outputs (as well as many others):

(7) GEN(*pakta*)

cand a	i = {p, a, k, t, i}	o = {p, a, k, t, i}	ℜ = {(p,p), (a,a), (k,k), (t,t), (i,i)}
cand b	i = {p, a, k, t, i}	o = {p, a, t, i}	ℜ = {(p,p), (a,a), (t,t), (i,i)}
cand c	i = {p, a, k, t, i}	o = {p, a, t, i}	ℜ = {(p,p), (a,a), (k,t), (t,t), (i,i)}
cand d	i = {p, a, k, t, i}	o = {p, a, k, u, t, i}	ℜ = {(p,p), (a,a), (k,k), (t,t), (i,i)}
cand e	i = {p, a, k, t, i}	o = {p, a, k, u, t, i}	ℜ = {(p,p), (a,a), (k,k), (a,u), (t,t), (i,i)}

In candidate (a) the input and output match exactly and the relation ℜ **covers** both sets. In candidates (b) through (e) the output fails to match the input along some dimension. These differences are also reflected in the relation ℜ. In both candidate (b) and candidate (c) the underlying segment *k* is not present in the output set. In candidate (b) the *k* is not present in the input and fails to show up in the correspondence relation. In candidate (c) the *k* is also not present in the output set, but does show up in the correspondence relation, being in correspondence with output *t*. Candidates (d) and (e) both have an extra segment, *u*, in the output set. In candidate (d) the *u* does not show up in the correspondence relation. In candidate (e) the segment *u* is in correspondence with the preceding vowel *a*. These four candidates are all separate candidates to be evaluated by the constraint hierarchy.

Note that in candidate (c), the one output segment has multiple correspondent input segments. Similarly with candidate (e), the one input segment, *a* , stands in a correspondence relation with two output segments, *a* and *u*. It is this freedom of the correspondence view of Faithfulness that will be crucial in explaining how geminate segments can be split into two surface

segments and how two separate underlying segments can coalesce to one surface segment.

Faithfulness between input and output is regulated by constraints which hold over the relation ℜ. The basic drive of faithfulness is that the two representations (input and output) should be identical. Different Faithfulness constraints mediate different aspects of that identity requirement. Examples of Faithfulness constraints are given in (8).

(8) *Faithfulness Constraints* (McCarthy & Prince 1995)

MAX Every element of S_1 has a correspondent in S_2.
Domain(ℜ) = S_1.

DEP Every element of S_2 has a correspondent in S_1
Domain(ℜ) = S_2.

IDENT(F) Correspondent segments have identical values for the feature F.
If $x\mathfrak{R}y$ and x is [γF], then y is [γF].

The constraint MAX requires that every segment of the input be present in the output. MAX is violated by phonological deletion of segments. The constraint DEP requires that every segment in the output be present in the input. DEP is violated by phonological insertion of segments. For both of these constraints a segment is present in the representation when it has a correspondent in the representation. IDENT(F) demands that correspondent segments agree for feature specifications. It is violated when two segments stand in correspondence, but do not match featurally.

These three Faithfulness constraints divide the phonological representation into two types of things. MAX and DEP hold over segments. In that way they quantify the segment. Segments are objects that must be preserved. IDENT(F) holds over features, but is mediated through segments. On the IDENT(F) view of faithfulness, features are properties of segments. This dissertation provides evidence for this fundamental difference between segments as objects and features as properties. This is contrary to the position that features are objects as in the MAX-FEATURE approach to faithfulness (Lombardi 1995, Causely 1996, LaMontagne & Rice 1995, Walker 1997). I'll discuss this issue in more detail in chapter two.

A further refinement of Faithfulness theory is Positional Faithfulness (Lombardi 1996a, Beckman 1996, 1997). In some languages we see that phonemic contrasts are maintained in strong positions, while neutralized in weak positions. These strong positions include stressed syllables, initial syllables and onsets. We can analyze these languages by positing that there are faithfulness constraints which are relativized to strong positions. That is, it is a worse violation of faithfulness to neutralize in a strong position than in a weak position.[2] The positional faithfulness constraint, IDENT-ONSET(F), from Beckman (1997) is given in (9).

(9) IDENT-ONS(F) Correspondent segments in onset must have identical specifications for [F].

Let β be an output segment in onset and α the input correspondent of β. If β is [γF], then α must be [γF].

The constraint states that segments which stand in correspondence, where one segment is in an onset, must have identical feature specifications. It will be violated by a segment in an onset which has changed feature specifications. I will argue that geminate fission is an effect of a high ranking IDENT-ONS(F).

The Correspondence Theory of faithfulness and Positional Faithfulness both play an important role in the analysis of the geminate typology in (5). Correspondence Theory allows segments to stand in multiple correspondence relations. Positional Faithfulness relativizes faithfulness to strong positions, a key element of geminate fission.

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[2] The alternative analysis is that there are markedness constraints relativized to weak positions. See Zoll (1998) for a discussion. The analysis of geminate behavior in this dissertation argues for the positional faithfulness view.

1.2 Moraic Theory and Faithfulness

Hayes (1989) (following Leben 1980, McCarthy 1979, etc.) argues that segmental length should be treated as an autosegmental feature. A key factor in this argument is that the length of a segment behaves like an entity independent of the segment. For example, when a segment deletes the corresponding timing unit of the segment can be transferred to another segment i.e., compensatory lengthening. For example in Latin an *s* was deleted before anterior sonorants. The deletion of the *s* affected the length of the preceding vowel as in (10).

(10) *Latin* s*-deletion* (Ingria 1980, reported in Hayes 1989:260)

*kasnus	→	ka:nus	'gray'
*kosmis	→	ko:mis	'courteous'
*fideslia	→	fide:lia	'pot'

The timing unit of the deleted *s* is transferred to the preceding vowel resulting in a long vowel.

Moraic Theory (Hyman 1984; 1985, McCarthy and Prince 1986, Hayes 1989) the moraic timing units serve two functions. Moras are part of syllabic structure, and distinguish heavy syllables from light syllables; a heavy syllable is bi-moraic (CVV or CVC) and a light syllable is mono-moraic (CV). In addition, since geminate consonants contribute to syllabic weight, they are represented as being moraic underlyingly. A geminate is distinguished from short consonant underlyingly by being associated to a mora as in (11).

(11) *Geminate/non-geminate Distinction*

a. Geminate: $/\overset{\mu}{\underset{|}{\text{t}}}/$

b. Non-geminate: /t/

When syllabified, the mora is incorporated into the syllable headed by the preceding vowel. The geminate is then further linked to the onset of a following syllable by universal principles of syllabification. The result is a doubly linked segment, which is interpreted as phonetically long. The non-geminate input, by contrast, is only syllabified to one syllable position in the output by the universal syllabification principles and thus interpreted as phonetically short. compare moraic theory with the Two-root theory (Selkirk 1990) where a geminate is long (having two root nodes) and is given syllabic weight by universal syllabification rules.

A key feature of moraic theory is that it treats long segments as single melodies which are associated to two timing units. They are not represented as a sequence of two shorter segments. This representational claim is supported by geminate behavior cross-linguistically. I will discuss this aspect of moraic theory in more detail in chapter two.

To integrate moraic theory into Optimality Theory, there must be faithfulness constraints that are sensitive to the underlying geminate/non-geminate distinction. Faithfulness to moras and mora associations is crucial to analyzing languages with surface length contrasts. Following McCarthy (1997) I assume that correspondence between the input and output ranges over moras and that there are MAX and DEP faithfulness constraints to moras as well as constraints demanding faithfulness to moraic association. The Mora Faithfulness constraints proposed by McCarthy (1997) are given in (12).

(12) *Mora Faithfulness*

MAX-$\mu_{S1\text{-}S2}$

Every mora in S_1 has a correspondent in S_2.

DEP-$\mu_{S1\text{-}S2}$

Every mora in S_2 has a correspondent in S_1.

NOSPREAD$_{S1\text{-}S2}(\tau, \zeta)$

Let τ_i and ζ_j stand for elements on distinct autosegmental tiers in two related phonological representations S_1 and S_2, where

τ_1 and $\zeta_1 \in S_1$

τ_2 and $\zeta_2 \in S_2$

$\tau_1 \Re \tau_2$, and

$\zeta_1 \Re \zeta_2$,

if τ_2 is associated with ζ_2,

then τ_1 is associated with ζ_1.

MAX-μ demands that moras in the input be present in the output. It is violated by any literal deletion of an input mora. DEP-μ demands that every output mora be licensed by an input mora. It is violated by insertion of a non-correspondent mora. NO-SPREAD(μ, Seg) demands that an output association between a mora and a segment is licensed by an input association between the correspondent mora and the correspondent segment. It is violated by any output association to a mora that is not in the input. I will assume these constraints with some minor revisions in this dissertation.

By having these three faithfulness constraints on moras and their segmental associations, moras are treated as both autosegments and properties of segments. MAX and DEP treat the moras as objects, demanding that they be preserved and or not inserted. This accounts for the autosegmental nature of length. Whereas NOSPREAD(μ, Seg) treats the mora as a property of the segment and vice versa, accounting for the linking between the segment and the timing unit.

1.3 Alterability vs. Inalterability

The second part of the answer as to why geminates may act differently than short segments rests in the interaction between phonological representations and the constraints responsible for phonological changes. In Optimality Theory phonology happens because of the interaction of conflicting output constraints. Therefore, whether or not a given constraint interaction produces inalterability or alterability of geminates depends on the nature of the constraints involved. In this section I will briefly discuss what types of constraints yield inalterability or alterability of geminates. To do so, we must first understand the mechanism of constraint interaction in an Optimality Theoretic system in some detail.

1.3.1 Output visibility

In order for a phonological change to occur to some segment in an Optimality Theoretic grammar, some constraint must prefer a non-faithful parse to the faithful parse of that particular segment. That is, some constraint must rule out all output candidates which have the segment faithfully rendered in them. Here I will lay out exactly what must be true in order for a constraint to rule out a candidate.

There are two conditions that must hold in order for a constraint to eliminate an output candidate. First, the constraint must dislike the output candidate. That is, the output candidate must be *more* marked with respect to that constraint than some other output candidate. Second, the constraint must be active on the candidate. That is, the fact that the constraint dislikes the output must cause the candidate to be discarded from consideration.[3]

We can define the first requirement as the notion *mark* as in (13).

(13) *Definition of Mark*

> Let C be a constraint in a constraint hierarchy CH and let o_j and o_k be output candidates of an input i. C *marks* o_j if some output o_k is more harmonic than o_j with respect to C.

It is important to understand that the notion of marking in Optimality Theory is relativized to the candidate set. A constraint only marks an output candidate if there is another output candidate which does better on that constraint. A simple violation of the constraint by an output candidate does not guarantee marking of the candidate. In (14) are some hypothetical candidates and their violations with respect to a constraint C.

[3] The notion of *active* used is here is slightly different from that in Prince & Smolensky (1993). Here activity is reckoned relative to a particular candidate whereas in Prince & Smolensky, activity is relativized to inputs.

(14) *Example of Marking*

Candidates	C
a. $cand_a$	*
b. $cand_b$	**
c. $cand_c$	***

In this tableau, only candidates (b) and (c) are marked by the constraint C. Candidate (a) violates the constraint C once, however it is not marked because no other candidate does better on the constraint.

However, in order for a constraint to actively mark an output, less marked competitors must not be eliminated by higher ranked constraints. That is, the marking of the constraint must not be masked by the concerns of higher ranked constraints. In (15) is an example of the deactivation of an unmarked candidate.

(15) *Example of Deactivation*

Candidates	C_1	C_2
a. $cand_a$	*!	*
b. ☞ $cand_b$		**
c. $cand_c$		***!

In this tableau the constraint C_1 dominates the constraint C_2. Therefore, candidate (c) is actively marked by C_2. However, candidate (b) is not actively marked by C_2, despite the fact that candidate (a) does better on C_2. Candidate (b) is optimal since C_1 deactivates candidate (a) with respect to candidate (b). When the constraint C_2 gets a crack at the candidate set, candidate (a) is no longer available. Active marking requires the confluence of two factors. First the candidate must be marked with respect to some other candidate, and second that candidate must not be deactivated by higher ranked constraints.

With the understanding of how an active constraint can mark a candidate and thus rule it out, we can now turn to the question of inalterability and alterability of geminates. The question we are interested in is this: given a phonology alternation for singletons what are the conditions which lead to inalterability of geminates and what are the conditions which result in alterability of geminates?

1.3.2 Phonological changes and geminates

The nature of phonological alternations can be broken down into two parts. First, some segment, X, is restricted from occurring in some position, A__B. Second, this restriction causes segment X to change to segment Y. In Optimality Theory a necessary condition for phonological change is the ranking of the constraints in the following schema.

(16) *Ranking schema for phonological alternations*

MARKAXB » FAITH(X,Y), MARKY

Here MARKAXB stands for the restriction against having segment X in the environment A__B. MARKY stands for all the constraints that dislike having segment Y on the surface. Faith(X,Y) stands for all the faithfulness constraints militating against having output segment Y stand as a correspondent to input segment X.

The constraint ranking can be informally stated as 'it is worse to have segment X in the environment A__B, than it is to change segment X into segment Y and to have segment Y in the output'. This ranking schema results in the following mappings, assuming no other constraints are relevant.

(17) *Mapping*

/X/	↦	X	In non A__B environments
/X/	↦	Y	In A__B environments

In the unmarked environment an underlying X is mapped onto a surface X (assuming no other change takes place). However in the marked environment, underlying X is mapped onto some locally unmarked option Y.

In Chapter three I discuss palatalization in Faroese. The ranking for Faroese palatalization in (18) is the like that in (16).

(18) *Faroese Palatalization Ranking*

*VELAR-I » IDENTPLACE, *PALATAL

The constraint *VELAR-I marks velars before high front and mid vowels. It corresponds to the schematic constraint MARKAXB. The constraint IDENTPLACE is the Faithfulness constraint that regulates changing velars to palatals and vice versa (FAITH(X,Y)). Finally *PALATAL is the markedness constraint that dislikes palatals in the output, i.e. MARKY.

Given that the ranking schema holds in a language for a singleton segment X, can we tell whether it will result in inalterability of alterability of geminates? With the definitions of marking and active marking outlined above, we can establish under what circumstances geminates will be alterable or inalterable.

In order for geminates to be inalterable under a ranking which produces singleton alterability, the markedness constraint responsible for the change in singletons must not actively mark the candidates with the faithful geminate. If the constraint does not actively mark these candidates, then no change will be required. There are two possible ways for the markedness constraint to be inactive on the faithful geminate candidate.

First, the faithful geminate candidate could be among the set of least marked candidates with respect to the markedness constraint. In this situation, geminate inalterability will be universal. No geminate will alter under pressure from the particular markedness constraint. For example, consider a geminate X in the environment A__B as an input to the constraint ranking in (16). The unaltered candidate is AXXB and a possible altered candidate is AYYB. Given the constraint ranking in (16) and the hypothesis that the candidate AXXB does better or ties on MarkAXB, inalterability is predicted universally.

(19) *Universal Geminate Inalterability*

/AXXB/	MARKAXB	FAITH(X,Y)	MARKY
a. ☞ AXXB			
b. AYYB	(*!)	*!	*

Since the top-ranked constraint, MARKAXB makes no decision between the two candidates or decides in favor of candidate (a), geminate inalterablity results.[4] The analysis of spirantization in Chapter four has this schematic ranking. The constraint NOSHORTCLOSURE is the markedness constraint. Geminate stops pass the constraint, therefore spirantization of these stops is universally banned.

Another possibility is that the specific markedness constraint does in fact prefer the altered candidate, but this candidate is deactivated by a higher ranked constraint. The result in this case is parochial inalterability since the inalterability depends on a language particular ranking. Consider the same ranking from (16) above. However, in this case, MARKAXB is violated by the candidate AXXB (inalterability) and satisfied by AYYB (alterability). In addition there is a markedness constraint against YY ranked above MARKAXB.

(20) *Parochial Geminate Inalterability*

/AXXB/	MARKYY	MARKAXB	FAITH(X,Y)	MARKY
a. ☞ AXXB		*		
b. AYYB	*!		*	*

MARKAXB prefers candidate (b) to candidate (a). However, candidate (b) is ruled out by the higher ranked MARKYY. Therefore, MARKAXB is deactivated with respect to candidate (a) and inalterability results. This

[4] Of course other constraints could prefer candidate (b) to candidate (a) giving alterability. The point here is that MARKAXB is powerless to force alterability.

ranking results in only parochial inalterability since reranking of MARKYY and MARKAXB results in a grammar that has alterability of geminates.[5] In Chapter four I discuss glide coalescence in Latin. In this analysis, ONSET is Markedness constraint MARKYY. ONSET is violated by coalescence of the geminate glide, and so coalescence is blocked in this language.

From the discussion of inalterability, it is clear what conditions need to hold in order for geminates to be alterable. If the relevant markedness constraint (the one driving the change in singletons) actively marks the faithful parse of the geminate and dominates all constraints which dislike the target change, then alterability will result. Consider the constraints in (19) above. As noted, if the constraint MarkYY is subordinate to MarkAXB, then geminates are alterable as in (20).

(21) *Geminate Alterability*

/AXXB/	MARKAXB	FAITH(X,Y)	MARKY	MARKYY
a. AXXB	*!			
b. ☞ AYYB		*	*	*

Since MARKAXB actively marks candidate (a) but not candidate (b), Candidate (b) is preferred. Note that reranking any of the three lower constraints above MARKAXB results in a different grammar. If FAITH(X,Y) or MARKY is dominant, then there will be no change in either singletons or geminates. If MarkYY is dominant, as in (19) above, then there will be a change with singletons, but not geminates as in the ranking in (20).

The Faroese palatalization I discuss in chapter three has the ranking in (21). As I mentioned above, the constraint *VELAR-I corresponds to the MARKAXB constraint. This constraint is violated by geminate velars which are before high or mid front vowels. Therefore geminates are alterable just as singletons.

[5] The constraint responsible for blocking geminate alterability does not have to be a Markedness constraint as in this example. A Faithfulness constraint could also block geminate alterability.

1.4 Outline of Dissertation

In chapter two I will give my proposal for deriving lexical OCP effects. The effects of the OCP applying in the lexicon is to block morpheme internal geminates from being pair geminates (a sequence of two identical segments). I propose that morpheme internal pair geminates universally neutralize with another input. In the unmarked case pair geminates coalesce and surface as singletons. In some environments, pair geminates neutralize with fissioned single geminates. Furthermore, the existence of pair geminates at morpheme boundaries requires a constraint against coalescence of segments with different morphological affiliation.

In chapter three I will discuss cases of alterability. These fall into two classes. Total alterability occurs when the positional faithfulness constraint IDENT-ONS(F) is inactive on the candidate set. Fission occurs when IDENT-ONS(F) is active on the candidate set. This constraint forces maintenance of underlying specifications in onset position and can thus split geminates.

In chapter four I will discuss cases of inalterability. These fall into two classes. Universal inalterability is the result of the geminate being unmarked by virtue of the constraint itself. The geminate passes the constraint to a sufficient degree to fail to undergo the change. Parochial inalterability results from blocking by a higher ranked markedness constraint.

In chapter five I conclude with a discussion of areas for future research.

2. Single Melody Geminates and the Nature of CON

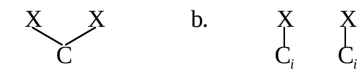
In this chapter I give evidence for the single melody theory of geminates. In addition, I show that the single melody theory of geminates places strong restrictions on the possible constraints in Universal Grammar. I propose an Optimality Theoretic Grammar which derives the single melody theory of geminates.

2.1 Single Melody Geminates

Two representations for geminate consonants are possible, the single and pair geminates respectively. These representations are given in (22).

(22) *Single vs. Pair geminates* (X = timing unit)

a. b.



Single geminates in (22a) have a single melody associated with two timing units. Pair geminates (22b) have two adjacent identical melodies. The representations in (22) are vague about the nature of the timing units (they are represented as simply Xs). At least two possibilities have been proposed. In Moraic Theory (Hyman 1984; 1985, Hayes 1986, McCarthy & Prince 1986) the timing units are syllabic positions, the syllable and mora nodes. Another possibility is that the timing units are root nodes as in the Two-Root Theory (Selkirk 1990). As noted in Chapter One, I will assume the Moraic Theory in this dissertation. Where relevant, I will point out differences between the two theories as well as arguments for the Moraic Theory over the Two-Root Theory.

2.1.1 Evidence for single melody geminates

The evidence for the single melody representation of geminates is the fact that geminates behave like one segment with respect to phonological processes. First of all, in contrast with consonant clusters, geminates are not split by epenthesis. That is, in a language which epenthesizes vowels to break up consonant clusters, and which has geminate consonants, epenthesis does not treat the geminate as a cluster and break the two halves. Furthermore, geminates generally undergo completely or fail to undergo phonological changes that affect singletons. Phonological changes do not treat the two halves of a geminate as separate segments, except under special circumstances.[6] Finally, no language which has geminates contrasts pair geminates with single melody geminates.

Palestinian Arabic (Abu-Salim 1980, Hayes 1986) is an example of an epenthesis process treating geminates and consonant clusters differently. Epenthesis occurs in Palestinian Arabic to break up consonant clusters at the end of the word or medially when they are longer than two consonants.

(23) *Epenthesis into CC clusters in Palestinian Arabic* (Hayes 1986)

a. /ʔakl/	→	ʔakil	'food'
b. /ʔakl kum/	→	ʔakilkum	'your food'
c. /jisr kbiir/	→	jisrikbiir	'big bridge'

Consonant clusters at the end of words, as in (23a), are broken up by the epenthetic *i*. Furthermore, medial clusters which are greater than two consonants in length are also broken up with the epenthetic vowel, as in (23b and c).

In contrast to consonant clusters, geminates are allowed in Palestinian Arabic finally and as the initial member of a medial consonant cluster.

(24) *No epenthesis into tautomorphemic geminates*

a. /ʔimm/	→	ʔimm, *ʔimim	'mother'
b. /sitt na/	→	sittna, *sititna	'grandmother'

[6] As I noted in Chapter One, cases of geminate fission do occur, where half of the geminate undergoes a change and the other half does not. I will argue in Chapter Three that these cases are special and support the single melody theory of geminates.

Epenthesis does not break up geminates which shows that they are not represented the same way as consonant clusters. I will give an analysis of these facts in Chapter Four which assumes a single melody input for geminates.

If we look at how segmental processes affect geminates, we see two patterns which also point towards a single melody theory of geminates. Either geminates fail to undergo segmental processes completely (inalterability) or they undergo these processes completely (total alterability). Both cases suggest that geminates are really one thing. These facts contrast with consonant clusters where the individual consonants that make up a cluster are generally free to undergo changes without regard to the other segments in the cluster.

A classic example of geminate inalterability is Tiberian Hebrew stop spirantization. In Tiberian Hebrew (Sampson 1973, Leben 1980) singleton stops spirantize post-vocalically, but geminate stops fail to spirantize post-vocalically.

(25) *Tiberian Hebrew Spirantization*

a. /gâdal/	→	gâðal	'he became great'
b. /miktab/	→	mixtaβ, *miktaβ	'letter'
c. /giddel/	→	giddel, *giðdel, *giððel	'he raised (educated)'

The underlying geminate stop in *giddel* does not spirantize. In addition, the geminate does not partially undergo spirantization which would be expected if the geminate were simply a consonant cluster. As example (b) shows the first member of a consonant cluster will spirantize. I will give an analysis of the inalterability cases in detail in Chapter Four as well.

Total alterability of geminates also indicates that they are single melodies. For example, in Faroese (Petersen, et al. 1998) singleton velars palatalize before *i*. In addition, geminate velars also palatalize before *i*.

(26) *Faroese Palatalization*

a. /va^{h}ki/ → va^{h}či 'wake' 1sg.

b. /la^{h}kːi/ → la^{h}čːi, *la^{h}kči 'lower' 1sg.

Palatalization of the geminate *kː* results in a geminate palatal, not palatalization of the first half of the geminate as would be expected if geminates were consonant clusters. I will give an analysis of these facts in Chapter Three.

Finally, to my knowledge, no language which has a length distinction in consonants contrasts pair geminates with single geminates (see McCarthy 1986, Hayes 1986 and references therein). That is, no language has both single melody geminates and pair geminates where the two types of geminates behave differently with respect to some phonological processes. These facts support the hypothesis that no language uses pair geminates as possible inputs. Rather, geminates are underlyingly single melody geminates.

The evidence from geminate behavior supports the hypothesis that all morpheme internal geminates are underlyingly single melodies and their length is a result of being associated to two timing units on the surface. In order to ensure this representation for geminates we must rule out the other possible representation, the pair geminate. There are really two parts to banning pair geminates. First, morpheme internal pair geminates can never appear on the surface. So, no phonological process can create a pair geminate and any posited underlying pair geminates must undergo some change. Second pair geminates cannot contrast with some other segment or group of segments. That is pair geminate inputs cannot surface as an output that differs from some other input. How do we account for the universal ban on morpheme internal pair geminates?

McCarthy (1986) proposes that the Obligatory Contour Principle (OCP) given here in (27) applies in the lexicon as well as to surface representations.

(27) *Obligatory Contour Principle*

At the melodic level, adjacent identical elements are prohibited.

Having the OCP apply in the lexicon prevents pair geminates from being possible underlying representations. Therefore no underlying pair geminates will threaten to surface as pair geminates or as anything else. Pair geminates are not possible contrasting structures to single melody geminates. The OCP also applies to surface representations. Therefore no phonological process can create a pair geminate on the surface.

The dual OCP approach to single melody geminates has the drawback of positing the same restriction on both inputs and outputs. This problem could be circumvented by stipulating that the OCP applies to all representations, both input and output. However, there is evidence that pair geminates are possible representations, occurring at morpheme boundaries. When the two segments of a pair geminate belong to separate morphemes, the pair geminate behaves like a consonant cluster in some languages and not like a single geminate. An example of pair geminates at morpheme edges occurs in Palestinian Arabic discussed in Hayes (1986).

As I mentioned above, Palestinian Arabic has epenthesis into consonant clusters. Epenthesis occurs when either there are two or more consonants at the end of a word, or when there are three or more consonants medially. However, epenthesis does not break up geminates.

(28) *Epenthesis in Palestinian Arabic*

a. /ʔakl/ ↦ ʔak**i**l 'food'

b. /ʔimm/ ↦ ʔimm, *ʔim**i**m 'mother'

In Chapter four I will give a complete analysis of the Palestinian Arabic facts. The key to understanding why epenthesis does not occur with tautomorphemic geminates is that they are single melodies and therefore resist splitting. This fact contrasts with what happens to heteromorphemic geminates. In (29) we see that epenthesis does occur between heteromorphemic geminates.

(29) *Epenthesis into heteromorphemic geminates*

/fut+t/ ↦ fut**i**t, *futt 'I entered'

When a suffix *t* is added to a root that ends in a *t*, a vowel is epenthesized between the two consonants. If the input form were not able to contain a pair geminate (as banned by the OCP), then we would expect a final geminate as in **futt*, parallel to the behavior of final tautomorphemic geminates (*?imm*). Therefore, we must allow pair geminates across morpheme boundaries.

Kirchner (1998a, b) suggests that pair geminates are not needed at morpheme boundaries. Rather, the pair geminate behavior seen there can be attributed to Output-Output correspondence (Benua 1995, 1997; Flemming 1995; Kenstowicz 1995; McCarthy & Prince 1995; Steriade 1996; Burzio 1997). I will show that pair geminates are needed at morpheme boundaries.

In Tigrinya (Schein 1981) velar stops are spirantized post-vocalically. As in Tiberian Hebrew spirantization does not occur with geminate velars.

(30) *Tigrinya Velar Spirantization*

a.	dəxam	'weakness'
b.	maχammaca	'buttocks'
c.	zaxti	'now'
d.	maχdəti	'instrument for well-digging'
e.	fakkara	'boast, 3m sg., perfect'
f.	raqqiq	'thin'

The examples in (30a-d) show post-vocalic spirantization of singleton velars, while those in (30e through f) show that morpheme internal geminates are inalterable. Geminates that arise through morpheme concatenation however, behave like consonant clusters and not morpheme internal geminates.

(31) *Hetero-morphemic geminates*

a. barak+ka baraxka, *barakka 'you-blessed, 2m sg., perfective'

With hetero-morphemic geminates, the first half of the geminate spirantizes but the second half does not. This is exactly like the consonant cluster examples in (c, d). The geminate is not inalterable as might be expect compared to tauto-morphemic geminates.

Kirchner (1998) attributes the fission of these hetero-morphemic geminates to Output-Output correspondence. Suppose that the base form of 'bless' is *barax* with spirantization of the final *k*. If an IDENT(F) constraint holds between the base form and the derived second masculine singular perfective form *baraxka*, then the spirantization of the final velar can be accounted for. Consider the following tableau where LAZY (Kirchner 1998) is the constraint forcing spirantization. The constraint LAZY requires that outputs reduce articulatory effort, preferring lenition of singletons and hardening of geminates.

(32) *Fission of hetero-morphemic geminates due to OO-CORRESPONDENCE*

Input: /barak:a/ *or* /barakka/ (base = [barax])	OO-IDENT(cont)	LAZY	IO-IDENT(cont)
a. barak:a	*!	*	
b. ☞ baraxka		**	*
c. barax:a		***!	

The constraint LAZY prefers the full geminate (candidate 11a) to the fissioned geminate (candidate 11b), however OO-IDENT(cont) blocks gemination and requires fission at the morpheme boundary. A geminate that is faithful to the base continuant is ruled out by LAZY since it requires more articulatory effort. No appeal is made to pair versus single geminate distinction in this analysis, so the input can contain a single geminate as demanded by the universal OCP.

There are two problems with the Output-Output correspondence account of hetero-morphemic geminates. First it does not adequately capture all of the facts of Tigrinya. Second, it is unable to account for the Palestinian Arabic epenthesis into hetero-morphemic geminates.

Schein (1981) shows that in addition to the morpheme *-ka*, Tigrinya has a 3rd feminine pronominal suffix, *-a*, which geminates the final consonant of the root to which it attaches. Geminates created by this affix behave like tauto-morphemic geminates in that they resist spirantization. The example in (33) provides a minimal pair with example (31).

(33) *Final geminate with no spirantization*

a. barak+a barak:a, *baraxka 'you-blessed, 2m sg. imperfective with 3f pro. suffix'

The Output-Output correspondence approach wrongly predicts that this form should be **baraxka*, like the example in (32) since the base form is exactly the same.

(34) *OO-Correspondence predicts wrong outcome*

Input: /barak:a/, /barakka/ (base = [barax])	OO-IDENT(cont)	LAZY	IO-IDENT(cont)
a. ☞ barak:a	*!	*	
b. ✗ baraxka		**	*
c. barax:a		***!	

Since the base form is exactly the same, output-output correspondence predicts candidate (34b), with fission as the optimal form. However, the actual form is candidate (34a) with gemination and no spirantization.

As Schein (1981) shows, the crucial difference between these two forms is the fact that in the first case the geminate consists of two separate

segments whereas in the second case, the geminate is one long segment. I will discuss such hetero-morphemic pair geminates further in section 3 below.

Another case where the Output-Output correspondence account is inadequate is the Palestinian Arabic epenthesis case. As I noted above, epenthesis occurs in consonant clusters and hetero-morphemic geminates, but not in tauto-morphemic geminates.

(35) *Epenthesis in Palestinian Arabic*

a. /ʔakl/ ↦ ʔak**i**l 'food'

b. /fut+t/ ↦ fut**i**t, *futt 'I entered'

c. /ʔimm/ ↦ ʔimm, *ʔim**i**m 'mother'

Crucially epenthesis only occurs medially with clusters of three or more consonants and finally with clusters of two or more consonants. There is no final epenthesis for example in forms that end in a single consonant.

There is no final epenthesis in Palestinian Arabic. Therefore, the base form of 'enter' is *fut* and not **futi*. As expected, the third person masculine past tense is uninflected and has no final epenthetic *i*.

(36) *No final epenthesis in Palestinian Arabic*

a. futit 'I entered'

b. fut 'he entered'

c. futu 'they entered'

Therefore the presence of the epenthetic *i* in *futit* cannot be attributed to Faithfulness to the base form. Again we have to recognize pair geminates as possible inputs at morpheme boundaries. The question remains, how can we ban the same inputs within morphemes?

A major claim of Optimality Theory is that lexical contrast, and the lack of lexical contrast, are both derivable from surface constraints. In the case of geminates, we can derive the effects of both the lexical OCP and the surface OCP from a set of surface constraints, allowing all possible inputs to be considered (*Richness of the Base*). In Section Two I propose a set of surface constraints which force pair geminate inputs to neutralize with a singleton segment generally. Thus pair geminates are not available as contrastive structures in any language.

2.2 Deriving the lexical OCP

'…one and one don't make two; one and one make one'
-Bargain
Pete Townsend

'tonight is the night when two become one'
-Tonight
The Spice Girls

In this section I show that the effects of the lexical OCP can be derived by a grammar which neutralizes underlying pair geminates with singleton segments. Neutralization occurs because the grammar prefers coalescence of identical adjacent segments to non-coalescence. That is, given a pair geminate input such as /tt/ the output will be a single segment, *t* as in (37).

(37) *Coalescence of underlying pair geminates*

/t_1 t_2/ → $t_{1,2}$

An important aspect of this idea is that pair geminates are neutralizing with single segments, not with single melody geminates. Since pair geminates neutralize with singleton segments, they cannot contrast with single geminates.

In section 2.1 I will discuss how phonological contrasts are modeled in Optimality Theory. Understanding how Optimality Theory models contrast allows us to understand the nature of the proposal. I give the proposal is section 2.2.

2.2.1 Contrast in OT

Contrasts arise in OT through the ascendance of Faithfulness constraints. Suppose there are two linguistic structures X and Y and some Faithfulness constraint which bans turning X into Y and vice versa. If that Faithfulness constraint dominates all markedness constraints which dislike either X or Y, then the language will contrast X and Y as inputs.

(38) *Contrast ranking*

FAITH(X, Y) » MARKX, MARKY

Contrast occurs in this language because underlying X must surface as X, it cannot be changed into Y, and underlying Y must surface as Y, it cannot be changed into X.

Tableau (39) shows how the ranking in (38) produces a contrast between X and Y.

(39) *Faith is dominant - contrasting inputs*

input /X/	FAITH(X, Y)	MARKX	MARKY
a. ☞ X		*	
b. Y	*!		*
input /Y/			
c. X	*!	*	
d. ☞ Y			*

Since Faithfulness is at the top of the hierarchy no change can occur in the mapping from input to output. In the top half of tableau (39a) wins the competition because it respects the dominant Faithfulness constraint. In the lower half of tableau (39d) wins for the same reason. Input X surfaces as output X and input Y surfaces as output Y.

A language which neutralizes X and Y has them both surface as the same thing, either X or Y. In a neutralizing grammar whether the inputs X and Y both surface as either X or Y depends on the relative markedness of the two structures. If one of the Markedness constraints that dislikes X or Y dominates the Faithfulness constraint and the other Markedness constraint then we have neutralization.

(40) *Neutralization Ranking*

a. MARKX » MARKY, FAITH(X,Y)

or

b. MARKY » MARKX, FAITH(X,Y)

Neutralization occurs because one of the inputs cannot surface faithfully and must change into the other input.

Assume for concreteness that MARKX is the dominant constraint. Tableau (41) shows how a ranking like that in (40a) produces neutralization of X and Y.

(41) *Faith is subordinate - contrasting inputs*

input /X/	MARKX	MARKY	FAITH(X, Y)
a. X	*!		
b. ☞ Y		*	*
input /Y/			
c. X	*!		*
d. ☞ Y		*	

In the competition between candidates (a) and (b) in the top half of tableau (41), candidate (b) wins since it satisfies MarkX and candidate (a) fails the same constraint. In the same way, (d) wins over (c) in the lower half of tableau (41). Because MARKX is the highest ranked constraint, it chooses output Y over output X regardless of the input. Thus the two inputs converge on the same output.

Without the Faithfulness constraint Faith(X,Y), the contrast ranking in (38) would be impossible. All inputs would converge on the least marked output (see McCarthy & Prince's 1994a discussion of the 'fallacy of perfection'). The core of my proposal is that the lack of contrast between true and fake geminates is the result of there being no faithfulness constraints

blocking the mapping of a fake geminate into a singleton segment and that singletons are universally less marked than fake geminates. The proposal places two strong restrictions on CON, the set of universal constraints. No Faithfulness constraint can require maintaining an input pair geminate. Furthermore, all Markedness constraints must prefer singletons to pair geminates on the surface. In this proposal, the OCP is promoted from a constraint on linguistic forms to a meta-constraint on grammars.

2.2.2 OCP as meta-constraint

The core of my proposal is that the OCP is really a constraint on the set of possible constraints in CON. As such there are two parts to it. First, no Faithfulness constraint can distinguish pair geminate inputs from singleton segments inputs. That is, Faithfulness constraints cannot see the distinction between one segment and two adjacent identical segments *in the input*. Second, Markedness constraints must prefer singleton segments to pair geminates in the output. In that way, pair geminates are more marked than singletons.

2.2.2.1 Faith is blind

In this section I will discuss four Faithfulness constraints and show how they need to be abandoned or reformulated under my proposal.

2.2.2.1.1 No Uniformity

McCarthy and Prince (1995) propose the faithfulness constraint UNIFORMITY which dislikes coalescence of segments generally.

(42) *Anti-Coalescence* (McCarthy & Prince 1995)

UNIFORMITY "No Coalescence"

No element of S_2 has multiple correspondents in S_1.

For $x,y \in S_1$ and $z \in S_2$, if $x\Re z$ and $y\Re z$, then $x=y$.

UNIFORMITY is proposed as a constraint to capture the fact that coalescence is a marked process. Coalescence only occurs under pressure from phonological constraints. However, UNIFORMITY dislikes the mapping of a pair geminate onto a single segment.

(43) *Pair geminate coalescence*

a. $/t_1t_2/$ → $t_{1,2}$ * UNIFORMITY

The mapping in (43a) violates UNIFORMITY since the output $t_{1,2}$ has two input correspondents.

If UNIFORMITY dominates all the markedness constraints that dislike pair melody geminates in some language, the language will contrast pair melody geminates and single segments.

(44) *Contrasting one and two*

input: $/t_1t_2/$	UNIFORMITY	MARK(tt)
a. ☞ t_1t_2		*
b. $t_{1,2}$	*!	
input: $/t_1/$		
c. t_1t_1		*!
d. ☞ t_1		

Because UNIFORMITY blocks merger the candidate with merger (44a), a pair geminate input surfaces faithfully. Pair geminates surface in the language despite their more marked status. A singleton input also surfaces faithfully. It does not fission into two segments since that is a more marked structure. My proposal is that the mapping in (44a) is impossible. Therefore UNIFORMITY must be rendered inactive.

A typical way of rendering constraints inactive in Optimality Theory is to posit universal rankings of constraints. For example Prince & Smolensky (1993) propose a consonant place subhierarchy where *LABIAL and *VELAR universally dominate *CORONAL. This ranking prevents the markedness of coronals from forcing all coronals to surface as, for example, the universally more marked velars. In this way the constraint *CORONAL is deactivated with respect to the constraints *LABIAL and *VELAR. In the same way, we

could posit that all markedness constraints that dislikes pair geminates dominate UNIFORMITY universally as in (45).

(45) *Universal subhierarchy*

MARK(PAIRGEM) » UNIFORMITY

With this universal ranking, languages would prefer to coalesce pair geminates rather than allow them to surface. However, positing this subhierarchy is not enough. Domination of a constraint does not guarantee its inactivity (see Prince 1997). Also, UNIFORMITY is not the only Faithfulness constraint that may dislike coalescence. Therefore MARK(PAIRGEM) must dominate all faithfulness constraints that dislike coalescence. This solution is clearly ad-hoc.

I propose that there is no UNIFORMITY constraint which penalizes coalescence of segments generally. Rather, coalescence is constrained by the IDENT family of constraints. Coalescence of unlike segments requires that the resulting segment assume the featural make-up of one of the underlying segments if the two segments have conflicting specifications for this feature. Because of this, IDENT(F) must be violated when unlike segments coalescence.

Coalescence of identical segments will not violate IDENT(F) since the segments agree on all feature specifications. Therefore Faithfulness will not block coalescence of identical segments as shown in tableau (46).

(46) *Coalescence of pair geminates*

input: $/t_1t_2/$	IDENT (F)	MARK(tt)
a. t_1t_2		*!
b. ☞ $t_{1,2}$		
input: $/t_1/$		
c. t_1t_1		*!
d. ☞ t_1		

Since Faithfulness (IDENT(F)) makes no decisions in either of the two competitions in tableau (46), Markedness constraints prefer the single segment outputs.

In conclusion, UNIFORMITY is not a constraint in Con. Therefore we should not see the effects of a general UNIFORMITY constraint cross-linguistically. This proposal has further consequences for the theory of segmental coalescence. Since coalescence is regulated by the IDENT(F) constraints it predicts that coalescence follows an implicational hierarchy. For example, suppose two segments that differ in two features coalesce in a language. This means that some phonological constraint dominates IDENT(F) for both of those features. Therefore, two segments which differ in only one of those two features will coalesce in the same environment in that language.

2.2.2.1.2 Output oriented IDENT(F)

‘When you look in the mirror do you see yourself
do you see yourself on the t.v. screen
do you see yourself in the magazine
when you see yourself does it make you scream?’
-Identity
X-ray Spex

By removing UNIFORMITY from CON, we can force pair geminates to neutralize to the corresponding singleton segment. What happens if singletons undergo a featural change in a language? Change in singletons in some grammar must entail coalescence and change for pair geminates in order to neutralize the two. Getting the proposed neutralization in these environments requires a reformulation of the IDENT(F) constraints.

Consider a language with complementary distribution between the velar stop *k* and the palatal *č*. In this language, the palatal occurs only before the high front vowel *i* and the velar occurs elsewhere. These mappings are summarized in (47).

(47) *Mappings*

a. /kX/ → kX, where X i

b. /čX/ → kX, where X i

c. /ki/ → či

d. /či/ → či

In this language, *k* and *č* neutralize to the velar when they do not occur before the high front vowel, (47a and b). However, before the high front vowel the neutralization goes the other way to the palatal, (47c and d).

The mappings in (47) are modeled in an Optimality Theoretic grammar with the constraint set in (48) and the ranking in (49).

(48) *Constraint set*

*VELAR	Do not have velar segments in the output.
*PALATAL	Do not have palatal segments in the output.
**ki*	Do not have *ki* in the output.
IDENT (place)	Correspondent segments have identical values for the feature place. If xℜy and x is [γplace], then y is [γplace].

The first two constraints are general markedness constraints against the segments in question. The third constraint is the specific markedness constraint that bans *k* before *i*. The final constraint is the Faithfulness constraint that dislikes a mismatch between input and output segments with respect to place of articulation features.

The constraint set is ranked as in (49) for this particular language.

(49) *Constraint ranking*

**ki*
|
*PAL
/ \
*VEL IDENT(place)

With **ki* above IDENT(place) and *PALATAL all input *ki* sequences will change to output *či* sequences. Furthermore, with *PALATAL above *VELAR and IDENT(place) all input *č*s not before *i* will surface as *k*s.

The neutralization of *č* to *k* before non high-front vowels is shown in (50) where the subscript *1* indicates which segments are in correspondence.

(50) *Neutralization of* č *to* k *in non-palatalization environments*

input: /...k_1a/	**ki*	*PAL	*VEL	IDENT (place)
a. [...$č_1$a]		*!		*
b. ☞ [...k_1a]			*	
input: /...$č_1$a/				
c. [...$č_1$a]		*!		
d. ☞ [...k_1a]			*	*

Both inputs in (50) surface with a velar since that is the least marked segment. Faithfulness is low ranked, so it cannot force a contrast.

The neutralization of *k* to *č* before high front vowels is shown in tableau (51).

(51) *Neutralization of* k *to* č *in palatalization environments*

input: /...k_1i/	**ki*	*PAL	*VEL	IDENT(place)
a. ☞ [...$č_1$i]		*		*
b. [...k_1i]	*!		*	
input: /...$č_1$i/				
c. ☞ [...$č_1$i]		*		
d. [...k_1i]	*!		*	*

In tableau (51) the high ranking **ki* is active and decides in favor of the palatal in the output for both inputs. Again, Faithfulness is low ranked and cannot force a contrast. An important point to note about the tableaux (50) and (51) is that *VELAR and IDENT(place) cannot be ranked with respect to each other. All decisions are made higher up in the constraint hierarchy, before they have a chance to be active.

The analysis of the complementary distribution of velars and palatals just presented is typical of how complementary distribution is modeled in correspondence theory (McCarthy & Prince 1995). Suppose we consider a pair geminate input to this constraint hierarchy. The tableau in (52) shows the result of this ranking given a pair geminate velar input preceding a high front vowel.

(52) *Potential contrast with pair geminates*

input: /...k_1k_2i/	**ki*	*PAL	*VEL	IDENT (place)
a. ? [...$č_{1,2}$i]		*		**
b. ? [...$k_1č_2$i]		*	*	*
c. [...$k_{1,2}$i]	*!		*	

Candidate (52c) with fusion of the two segments but no featural change is ruled out by the high ranking markedness constraint that is driving the palatalization. However, the ranking as it is given so far, does not decide between candidates (52a) and (52b). Under the definition of IDENT(F) given in Chapter one, which compares input and output correspondents and assigns a violation for each featural difference, candidate (52a) violates IDENT(place) twice. Each input is specified as velar, but the coalesced output (which is in correspondence with both input segments) is palatal. Candidate (52b) only violates IDENT(place) once, since there is no coalescence and only the segment immediately adjacent to the high vowel changes. However, candidate (52b) incurs a *VELAR violation whereas candidate (52a) does not. The decision between (52a) and (52b) now rests on the relative ranking of *VELAR and IDENT(place) a ranking that was not crucial in the previous tableaux.

Under the assumption that any other markedness constraints that would distinguish these two candidates (for example a syllable contact constraint) are ranked lower in the hierarchy than these two constraints, the output of the competition in (52) will be decided on the relative ranking of *VELAR and IDENT(place). In order to block candidate (52b) from surfacing, *VELAR must dominate IDENT(place). However, we know that velars are marked with respect to other place of articulation specifications, specifically coronals. Therefore, ranking *VELAR above IDENT(place) would result in all input velars becoming some less marked segments, perhaps coronals. The language then would not have velars on the surface. Therefore we cannot rely on the ranking *VELAR over IDENT(place) to account for this problem.

The problem is with IDENT(F) in this system. Whenever you have a phonological change forced through the domination of IDENT(F) by a markedness constraint, the behavior of underlying pair geminates is determined by the relative ranking of IDENT(F) and markedness. In just these situations IDENT(F) cares whether coalescence with change, i.e. k_1k_2 a c&$_{1,2}$, between underlying identical elements has occurred.

The problem arises because IDENT(F) quantifies over mappings. I propose that IDENT(F) is better understood as looking at output segments and determining whether they differ from their input correspondents. Output oriented IDENT(F) is defined in (53).

(53) *Output oriented IDENT(F)*

IDENT(F) An output segment has the same feature values as all its input correspondents.

Let $y \in S_2$.

For all $x \in S_1$ where $x\Re y$, if y is [γF] then x is [γF].

The important change is that output oriented IDENT(F) counts one violation for each output *segment* that fails to agree with an input correspondent. It no longer counts a violation for each imperfect correspondence relation. The effect of the reformulation of IDENT(F) in (53) is that the number of corespondent input segments is irrelevant. If any one or more of the input correspondents disagrees with the output segment for some feature specification, IDENT(F) is violated.

We can see that the output oriented IDENT(F) constraint rescues the desired result in tableau (52) repeated here as (54).

(54) *Coalescence in the face of change*

input: /...k_1k_2i/	**ki*	*PAL	*VEL	IDENT(place)
a. ☞ [...$\check{c}_{1,2}$i]		*		*
b. [...$k_1\check{c}_2$i]		*	*!	*
c. [...$k_{1,2}$i]	*!		*	

Both candidate (54a) with coalescence and candidate (54b) without violate the reformulated IDENT(place) equally. The output segment $\check{c}_{1,2}$ in candidate (54a) has a different place specification than both of its input correspondents. But IDENT(place) is violated once because we are not quantifying over correspondence relations, but output segments. The same is true for candidate (54b). The output segment $\check{c}_2$ in candidate (54b) violates IDENT(place) once because it has a different place specification than its only input correspondent. Because candidates (54a) and (54b) tie on IDENT(place) and *PALATAL, candidate (54b) is harmonically bounded by candidate (54a) under the reasonable assumption that there are no other constraints that would favor (54b) over (54a).[7] Therefore coalescence is still universally preferred even when it brings a segment into the environment for phonological change.

One benefit of the output oriented IDENT(F) is that it makes sense of faithfulness constraints that are sensitive to output structure, such as syllabification. For example positional identity constraints (Beckman 1997) can be defined more clearly with output oriented IDENT(F).

(55) *Positional Identity*

IDENT-Pos (F) Output segments parsed in position X have identical feature values as all their input correspondents.
Let $y \in S_2$ such that y is parsed in position X.
For all $x \in S_1$ where $x\Re y$, if y is $[\gamma F]$ then x is $[\gamma F]$.

Since IDENT(F) scans output segments it is clearer why it can be sensitive to output structure.

I have shown that in order to maintain coalescence of like segments in environments where a segment undergoes featural change, The IDENT(F) constraints cannot quantify over correspondence relations. That is, they cannot count two identical input segments differently than one input segment. Rather, IDENT(F) is output oriented, reckoning violations for each changed output segment. Reformulation of IDENT(F) along these lines also gives insight into how these Faithfulness constraints may be sensitive to the output structure of segments as in Positional Faithfulness constraints.

[7] IDENT-ONS(place) does not decide between the two since it is violated equally in both. See Chapter three for discussion.

2.2.2.1.3 MAX(F)

Standard correspondence theory with MAX, DEP and IDENT(F) ranging over segments has difficulty incorporating autosegmental theory (Goldsmith 1976, McCarthy 1979, Clements & Keyser 1983). A key insight of autosegmental theory is that features may behave like independent units. For example, features sometimes remain when the segments they are associated with delete. The feature nasal often behaves this way, coda deletion of nasals may result in the nasality remaining, but reassociating to the preceding vowel. Some researchers (Lombardi 1995, Causely 1996, Walker 1997) have proposed extending the correspondence relation so that it holds between features as well as segments to account for this autosegmental behavior. In this view, MAX and DEP constraints also range over features.

The view of featural change in this theory is that it is the deletion and insertion of features as in (56).

(56) *Featural change as deletion/insertion*

a. /n/ → t (deletion)
   |
   $[\text{nas}]_1$

b. /t/ → n (insertion)
         |
         $[\text{nas}]_1$

Changing a nasal to an oral stop as in (56a) requires the deletion of a feature. The feature $[\text{nas}]_1$ in the input has no correspondent in the output. Therefore this change violates MAX(nas). Changing from an oral stop to a nasal as in (56b) requires the insertion of a feature. The feature $[\text{nas}]_1$ in the output has no correspondent in the input. Therefore nasalization violates DEP(nas). In this theory, the IDENT(F) family of constraints does not exist.

Viewing featural change as the literal insertion or deletion of features requires MAX and DEP constraints for features. The following definition of MAX-IO FEATURE is from Walker (1997).

(57) *MAX-IO FEATURE* (Walker 1997)

Every occurrence of a feature specification [γF] in the input has a correspondent in the output.

The MAX-FEATURE constraint requires that every feature in the input have a correspondent output. It will be violated by any deletion of a feature.

One problem with the correspondence view of features is that it is unclear how to deal with mismatches between features that stand in correspondence. The standard Correspondence view of segmental faithfulness allows for segments to be in correspondence even though they have different features. For example the mapping in (58) satisfies the constraint MAX-IO, even though the output segment is not a perfect match of the input segment.

(58) *Max is satisfied by imperfect matching*

$/k_1/ \rightarrow t_1$

The input k_1 still has a correspondent in the output (t_1). The problem is that the output correspondent does not perfectly match the input. The crucial distinction is between the presence versus absence of a segment and the degree to which two segments match.

Discussion of these two dimensions of correspondence theory with respect to featural correspondence has been absent in the MAX(F) literature. In practice, it is assumed that MAX-IO Feature for example requires not only correspondence but identity as well. For privative features, this assumption is understandable. If there is only presence or absence of a privative feature, then there can be no imperfect matches between correspondents. However, for non-privative features the question of how to deal with imperfect correspondence arises. For example, suppose, as above, you have an input /k/ which surfaces as an output *t*. Can you satisfy MAX[dorsal] with an output [coronal] feature?

(59) *Featural mismatch*

a. /k/ → t
$[\text{dor}]_1$ $[\text{cor}]_1$

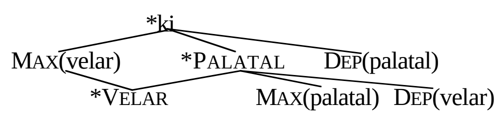
b. /k/ → t
$[\text{dor}]_1$ $[\text{cor}]_2$

If the mapping in (59a) satisfies MAX[dorsal] and there is no IDENT[place] constraint, then there is no faithfulness violation in the mapping and (59a) should universally be preferred to (59b) which violates MAX[dorsal] and DEP[coronal]. Therefore, mappings like that in (59a) must be banned, meaning correspondence can only hold between identical features.

The constraint MAX-IO FEATURE is problematic from my proposal since it treats features as objects that must be maintained in the output. It is necessarily input oriented (as MAX-SEGMENT). Therefore it counts individual input segments. This feature makes it impossible to allow coalescence and change of two segments as discussed above with the output-oriented IDENT(F).

Consider how the palatalization mapping in (54) would work under the MAX(F) approach. In (60) I show the relative constraint rankings needed to analyze the palatalization of velars before high front vowels discussed above.

(60) *Palatalization ranking*



Palatalization requires MAX(velar), DEP(palatal) and *PALATAL to be dominated by the palatalization constraint *ki. Palatalization must be able to create a palatal from a velar, therefore the output must be unfaithful to the underlying velar feature (violate MAX(velar)), and insert a palatal feature (violate *PALATAL and DEP(palatal)). In non-palatalizing environments, velars must be preserved and palatals neutralized to velars. Therefore, MAX(velar) must dominate *VELAR to prevent velars from neutralizing to a less marked outcome. Furthermore, palatals must be neutralized to velars in non-palatalizing environments. *PALATAL must dominate *VELAR, DEP(velar) and MAX(palatal), allowing this change.

Consider a pair geminate velar as an input to the hierarchy in (60). The desired outcome for this input is coalescence of the velars to a palatal. However, recall that in the IDENT(F) case there was another mapping where one of the velars was preserved. In (61) I show the competing mappings under the MAX(F) hypothesis.

(61) *Pair geminates with MAX(F)*

a. /k k/ a č
[velar]$_1$ [velar]$_2$ [palatal]

b. /k k/ a k č
[velar]$_1$ [velar]$_2$ [velar]$_1$[palatal]

The mapping in (61a) violates MAX(velar) twice since neither of the two velar features in the input is reaized on the surface. It also violates DEP(palatal) once since the output palatal feature has no input correspondent. The mapping in (61b) also violates DEP(palatal) once for the same reason. However, this mapping only violates MAX(velar) once. Therefore, Max(velar) prefers candidate (b) to candidate (a) and the mapping in (a) cannot be universal.

(62) *Potential contrast with pair geminates*

input: /...k$_1$k$_2$i/	**ki*	*PAL	*VEL	MAX(velar)	DEP(palatal)
a. ? [...č$_{1,2}$i]		*		**	*
b. ? [...k$_1$č$_2$i]		*	*	*	*

As in tableau (52) above, The relative ranking between *VELAR and Faithfulness determines the outcome of the competition between candidates (a) and (b). The problem is that MAX(f) cannot be reformulated the way

IDENT(F) can to avoid this problem. Therefore the Max(F) approach to featural faithfulness is incompatible with the theory of the lexical OCP presented here.

An alternative approach to capturing autosegmental effects is to atomize the segment. One could posit that segments consist of a number of nodes that hold features. These nodes all have MAX constraints associated with them. Coalescence can occur between them for free. This seems like a reasonable representation of tone. There are two parts to tonal structure, the Tone node (which may stand in a correspondence relation) and the tonal melody (which is a property of the tone node). In the discussion of Icelandic preaspiration in Chapter three I attempt to implement such a system.

2.2.2.1.4 No No-Spread

Another Faithfulness constraint that is problematic for the hypothesis presented here is the constraint that mediates the preservation of moraic association. For concreteness, I will assume McCarthy's (1997) version of the constraint, NO-SPREAD. The constraint WEIGHT-IDENT (Urbanczyk 1995) has the same problem.

(63) *Faith to Mora Association*

NOSPREAD$_{S1\text{-}S2}$(τ, ζ)

Let τ_i and ζ_j stand for elements on distinct autosegmental tiers in two related phonological representations S_1 and S_2, where

τ_1 and $\zeta_1 \in S_1$

τ_2 and $\zeta_2 \in S_2$

$\tau_1 \Re \tau_2$, and

$\zeta_1 \Re \zeta_2$,

if τ_2 is associated with ζ_2,

then τ_1 is associated with ζ_1.

The constraint NO-SPREAD blocks three types of mappings. It blocks spreading of a mora to a second segments as in (64).

(64) *Mora Spread*

Spreading of the mora in (64) violates No-Spread since the segment y in the output is associated to the mora, but the input correspondent of y is not. No-Spread also blocks flopping as in (65).

(65) *Mora Flopping*

Mora flop in (65) violates No-Spread for the same reason that mora spreading does. The only difference between flopping and spreading is that spreading maintains the original mora association to the segment x. Finally, No-Spread blocks segmental spreading of the type in (66).

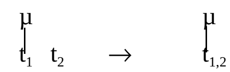
(66) *Segment Spread*

Segmental spread in (66) violates No-Spread because the segment x in the output is associated to μ_2 but it is not associated to that mora in the input.

The constraint No-Spread, is output oriented and symmetrical. It demands that moras associated to segments in the output be associated to those segments in the input and that segments associated to moras in the output be associated to those moras in the input. In that way, No-Spread (McCarthy 1997) treats moras as properties of segments and is similar to Ident(F).

The constraint No-Spread is problematic from the perspective argued for here. For example, No-Spread will block coalescence between a moraic segment and a non-moraic segment.

(67) *No-Spread blocks coalescence*



The mapping in (67) violates No-Spread, since the segment t_2 in the input is non-moraic and in the output it gains a mora. The mapping is a type of mora spread. If No-Spread dominated the Markedness constraints against pair geminates in some language, coalescence like in (67) would be blocked. Blocking of coalescence in this case is an undesirable result. Such a language would allow clusters of like consonants only if one of them was a geminate. Languages like this do not appear to be attested.

I propose that the No-Spread constraint only cares that the mora is anchored to the same segment in both the input and output. Therefore adding a mora to a segment is free but delinking a mora from a segment is penalized. The revised No-Spread, which I call Max-Association is given in (68).

(68) *Revised No-Spread*

Max-Association

If τ_1 is a mora in the input and it is associated to ζ_1 and $\tau_1\Re\tau_2$, and $\zeta_1\Re\zeta_2$ then τ_2 is associated to some ζ_2.

Under Max-Association, adding a segment to a mora is allowed, however deleting a segment from a mora is blocked. Max-Association treats segments as properties of moras, but not vice versa.

A further consequence of this formulation is that Max-Association is not violated by geminate fission. Fission results in the mapping in (69).

(69) *Geminate Fission*

No-Spread would be violated by fission since the segment y_1 is not moraic in the output but has a correspondent (x_1) in the input which is moraic. The constraint Max-Association is not violated by fission since at least on eof the output correspondents of x_1 maintains the association to the mora. In Chapter three I will discuss geminate fission in more detail.

2.2.2.1.5 Conclusion

In order for pair geminates to neutralize with singleton segments, Faithfulness constraints cannot block coalescence of identical adjacent segments. Here I have discussed four Faithfulness constraints from the Correspondence Theory literature. The constraint UNIFORMITY must be abandoned. UNIFORMITY is subsumed to IDENT(F). The constraint IDENT(F) must itself be reformulated so that it does not quantify over correspondence relations. The constraint MAX-FEATURE must be abandoned since its input oriented nature necessarily objectifies features, demanding that every feature in the input be realized in the output. Finally, the constraints NO-SPREAD or WEIGHT-IDENT must be reformulated so that moras are not treated as features of segments but rather the association between mora and segments is what is preserved.

2.2.2.2 One is better than two

The other constraint imposed on CON by the analysis adopted here is that Markedness constraints must prefer the singleton to the pair geminate universally. Since Faithfulness does not distinguish between the two outputs, Markedness must decide in favor of the singleton.

General Markedness constraints which dislike particular segments or feature combinations are used widely in the Optimality literature (Prince & Smolensky 1993, etc.). Examples of these constraints are given in (70).

(70) *General Markedness Constraints*

*STOP Do not have stop segments in the output

*VOICEDOBS Do not have voiced obstruents in the output.

These constraints mark specific segments and/or features. General Markedness constraints are gradeably violable, so that the more instances of a marked segment or feature present in the output representation, the more it violates of the constraint. Since pair geminates are bisegmental they necessarily violate these General Markedness constraints twice as much as the corresponding singletons. Therefore, one is preferred to two with respect to General Markedness constraints.

Prosodic Markedness constraints regulate the types of prosodic structure allowed. They include constraints like those in (71).

(71) *Prosodic Markedness*

NOCODA Codas are not allowed.

*COMPLEX Complex syllable positions are not allowed.

Prosodic Markedness constraints, with the exception of the ONSET constraint, ban prosodic structure. Under the assumption that all segments must be parsed into prosodic structure, the more consonants you have the more prosodic structure you will need to accommodate them. Therefore, more consonants leads to worse Prosodic Markedness violations (more corresponding prosodic structure).

Although ONSET demands structure, an onset position, it does not prefer two to one. Onset is satisfied equally by both a single onset segment and a complex onset of two or more segments. Therefore, as long as other constraints like *COMPLEX militate against two segments, ONSET cannot force more than one onset segment. Again, one is preferred to two with respect to prosodic markedness.

Interestingly, under this hypothesis, Prosodic Markedness constraints cannot demand more structure (i.e. hypothetical HAVECODA). Two constraints proposed, SYLLABLE-SEGMENT (Rosenthall 1994) and CRISPEDGEμ (Baker 1998) have exactly this property.

The constraint CRISPEDGEμ demands that moras do not share segments with other prosodic categories. The definition of the constraint is given in (72).

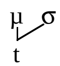
(72) *Crisp Edge* Baker (1998)

CRISPEDGEμ Moras are crisp.

Let A be a terminal (sub)string in a phonological representation, C is a category of type Pcat, and A be-the-content-of C. Then C is crisp if and only if A is-a Pcat.

CRISPEDGEμ requires that any material dominated by a mora be dominated exclusively by the mora. It is violated by a single melody geminate as in (73).

(73) *Non-crisp single melody geminate*



The structure in (73) violates the CrispEdgeμ requirement because the segment *t* is not exclusively moraic. The *t* is also linked to the following syllable node.

A similar constraint has been proposed by Rosenthall. The constraint SYLLABLE-SEGMENT (Rosenthall 1994) is given in (74).

(74) *Syllable to segment association* Rosenthall (1994)

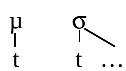
SYLLABLE-SEGMENT (SYLL-SEG)

if rt_i is linked directly to σ, then $*\mu_i$.[8]

This constraint bans a root node from being associated with both a mora and a syllable node. Again, the representation of geminates in (73) violates this constraint.

The problem with both of these markedness constraints is that they are satisfied by a pair geminate. For example, consider the representation in (75)

(75) *Pair geminate passes CRISPEDGEμ and SYLL-SEG*



[8] The subscripts in Rosenthall's definition of SYLL-SEG represent associations between prosodic and segmental objects.

The pair geminate in (75) satisfies both of these constraints since the two *t*s belong to separate root nodes. In the case of CRISPEDGEμ, it is satisfied since the mora dominating the first *t* only dominates the first *t*.[9] SYLL-SEG is also satisfied since the *t* associated to the syllable node is not the same *t* associated to the mora. Since pair geminates pass these constraints and single melody geminates fail them, these constraints could create pair geminates from input singleton geminates. Therefore, these constraints cannot be part of CON. McCarthy (1999) presents additional arguments from the typology of syllable types that these constraints are not possible members of CON.

A third type of Markedness constraint that I refer to as Specific Markedness constraints have also been proposed. An example of this type of constraint is the sequencing constraint *NC (Pater 1995).

(76) *Specific Markedness*

*NC No nasals followed by voiceless stops. (Pater 1995)

Specific Markedness constraints are special cases of the General Markedness constraints discussed above. They do not make reference to prosodic structure therefore their effects are strictly local. They cannot see outside of their domain and don't prefer one to two or two to one.

2.2.3 Conclusion

As long as Faithfulness constraints do not mark coalesced pair geminates and pair geminates are less harmonic than singletons with respect to Markedness constraints, then pair geminates will universally coalesce to singletons. Under the constraint set proposed here, /...tt.../ can never surface as a fake geminate. Therefore, geminates must be specified underlyingly as prelinked to a timing unit as in Moraic Theory (Hyman 1984; 1985, Hayes 1986, McCarthy and Prince 1986).

[9] Baker (1998) does not assume the Moraic theory of geminates, but rather uses the Two-Root theory. However, the criticism of CRISPEDGEμ here applies to the Two-Root theory as well. The problematic candidate for the Two-Root theory has two Place nodes rather than two segments.

2.3 Pair Geminates at Morpheme Edges

I have shown that restricting the universal constraint set in the ways mentioned above allows us to capture the universal ban on morpheme internal pair geminates. However, pair geminates do occur at morpheme edges indicating that we need to use the pair geminate representation. An example of pair geminates at morpheme edges occurs in Palestinian Arabic discussed in Hayes (1986).

As I discussed above, Palestinian Arabic has epenthesis into consonant clusters. Epenthesis occurs when either there are two or more consonants at the end of a word, or when there are three or more consonants medially. An example is given in (77).

(77) *Epenthesis into CC clusters*

/ʔakl/ ↦ ʔakil 'food'

A rough analysis of the epenthesis process (see Chapter four for a more detailed analysis) is that the active constraint is a constraint against complex syllable positions (codas or onsets). I will assume this constraint is *COMPLEX given here in (78).

(78) *No complex syllable positions*

*COMPLEX Codas and onsets are simple (do not branch).

This constraint conflicts with and outranks the Faithfulness constraint DEPIO which militates against epenthetic segments as in (79).

(79) *Epenthesis ranking*

*COMPLEX » DEPIO

The ranking in (79) indicates that epenthesis will occur in Palestinian Arabic to avoid violation of *COMPLEX. Of course other constraints must be ranked with respect to DEPIO in order to ensure that epenthesis and not deletion occurs, as well as to determine the exact location of the epenthesis site. I will ignore these details here.

A surprising fact about the epenthesis in Palestinian Arabic is that it does not occur between tautomorphemic geminates as in (80).

(80) *No epenthesis into tautomorphemic geminates*

/ʔimm/ ↦ ʔimm, *ʔim**i**m

In Chapter four I will give a complete analysis of these facts. However, they key to understanding why epenthesis does not occur here is that tautomorphemic geminates are single melodies and therefore resist splitting. This fact contrasts with what happens to heteromorphemic geminates. In (81) we see that epenthesis does occur between heteromorphemic geminates.

(81) *Epenthesis into heteromorphemic geminates*

/fut+t/↦ fut**i**t, *futt, *fut

When a suffix *t* is added to a root that ends in a *t*, a vowel is epenthesized between the two consonants., A geminate *t* is not created. Also, the two *t*s do not fuse into a singleton.

I propose that there is a constraint which bans coalescence of segments which belong to different morphemes. That is, CON contains the following constraint against morphological coalescence.

(82) *Anti-Morpheme coalescence*

MORPHDIS (McCarthy & Prince 1995)

Morphemic disjointness. Distinct instances of morphemes have distinct contents, tokenwise.

$x \subset M_i \rightarrow x \not\subset M_j$, for instances of morphemes M_i M_j and for x a specific segmental token.

The MORPHDIS constraint is violated whenever two morphemes share an output segment. Coalescence of two segments from different morphemes creates the banned overlapping structure.

In Palestinian Arabic, MORPHDIS dominates DEPIO, forcing epenthesis over fusion. The tableau in (83) shows the ranking argument.

(83) *Input is pair geminate across morpheme edge*

input: /fut$_1$ + t$_2$/		*COMPLEX	MORPHDIS	DEPIO
a.	☞ fut$_1$it$_2$			*
b.	fut$_{1,2}$		*!	
c.	fut$_1$t$_2$	*!		

Candidate (83c), the pair geminate, is ruled out because of the already established ranking of *COMPLEX above DEPIO. Candidate (83b), with coalescence, wins when the pair geminates is morpheme internal. However, since the two coalescing segments each belong to separate morphemes, MORPHDIS is violated by this candidate. Therefore MORPHDIS must dominate DEPIO, making candidate (83a) optimal.

Ranking DEPIO above MORPHDIS predicts that the language will choose coalescence at morpheme boundaries.

(84) *Coalescence at morpheme edges*

DEPIO » MORPHDIS

In this language affixes which are identical to their adjacent stem consonants will coalesce as in (48).

(85) *Input is pair geminate across morpheme edge*

Candidates		*COMPLEX	DEPIO	MORPHDIS
a.	fut$_1$it$_2$		*!	
b.	☞ fut$_{1,2}$			*
c.	fut$_1$t$_2$	*!		

Under this ranking, candidate (b) wins despite the MORPHDIS violation. de Lacy (1998) analyzes cases of morphological haplology in Japanese, French and Arabic as coalescence between affixal material and stem material, violating MORPHDIS.

2.4 Conclusion

In this chapter I have shown that the behavior of geminates with respect to phonological processes supports the hypothesis that geminates are single melodies rather than pair melodies. I have proposed an OT grammar that neutralizes pair geminates with singleton segments universally. In that way, pair geminates are not possible representations for morpheme internal geminates. This hypothesis places two restrictions on CON, the universal set of constraints. First, Faithfulness must not see the difference between pair geminates and singletons. I have shown how this restriction argues against four proposed Faithfulness constraints. Second, Markedness constraints must also universally prefer one segment to two adjacent identical segments. These restrictions on CON have broad consequences for the theory of segmental fusion as well as syllabic well-formedness.

The analysis of Lexical OCP effects presented here makes no use of the OCP, either as a ranked and violable constraint or as a universal condition on representations. Rather, the analysis relies only on general markedness considerations to force pair geminates to neutralize with singletons. It is an open question whether a ranked and violable OCP constraint is required. For example, Alderete (1997) and Itô & Mester (1998) propose that dissimilation phenomena, formerly attributed to the OCP, can be accounted for with local conjunction of Markedness constraints. Also de Lacy (1998) argues that haplology is better understood as a reduction of featural markedness through coalescence than the desire to avoid sequences of identical strings.

3. Geminate Alterability

3.1 Introduction

Although geminate inalterability has received much attention in the literature, cases of geminate alterability also exist. That is, geminates may undergo processes that singleton segments also undergo in the same environment. Cross-linguistically we see that there are two ways that a geminate may be affected by a phonological change. These effects, geminate fission and total alterability, are shown schematically in (86).

(86) *Geminate Alterability*

a. Geminate fission

$C_i^\mu \mapsto C_jC_i$ (not C_iC_j)

b. Total alterability

$C_i^\mu \mapsto C_j^\mu$

In geminate fission, an underlying single geminate is split into a sequence of like segments where one segment is altered and one segment is not. There is an asymmetry in cases of attested geminate fission. There are a number of cases where a phonological change alters the first half of the geminate and not the second. For example in Alabama geminate *b*'s are fissioned into sequences of a nasal plus the voiced stop, i.e. *mb*. However, there are no cases where a phonological process alters the second half of the geminate to the exclusion of the first. No language fissions geminate *b*'s into a sequence of a voiced stop followed by a nasal, i.e. *bm*. Total alterability, by contrast, leaves the geminate whole. The change affects the entire geminate. For example in Faroese, palatalization of geminate velars results in a palatal geminate (i.e., *č:*).

Geminate alterability is due to the relative markedness of the geminate. If a geminate is marked, either generally or in some context, the geminate will be under pressure to alter. I propose that geminate alterability in Optimality Theory occurs when a constraint actively marks candidates containing the faithful geminate. Since these candidates are actively marked they are eliminated from the competition.

For example, suppose we have a language that changes the singleton segment X to the segment Y in the environment A__B. In Optimality Theory, this mapping requires the ranking *AXB » FAITH, MARKYGENERAL. Where *AXB is a specific markedness constraint that militates against X in the environment A__B; FAITH is the Faithfulness constraint that wants to preserve underlying X; and MARKYGENERAL represents all constraints that dislike inserting Y in the environment A__B. The tableau in (87) shows how an altered geminate will be optimal if *AXB actively marks the faithful geminate candidate AXXB.

(87) *Phonology happens to geminates*

/AXXB/	*AXB	FAITH	MARKYGEN
a. AXXB	*!		
b. ☞ AYYB		*	*
c. ☞ AYXB		*	*
d. ☞ AXYB		*	*

In order for geminates to be altered, the markedness constraint *AXB must actively mark the faithful geminate candidates (candidate a) and force violation of a relevant faithfulness constraint. Under this ranking, one of the altered candidates (b through c) will be optimal.

For example, suppose the markedness constraint *AXB is a markedness constraint against geminate continuants *GEMCONT, the faithfulness constraint is IDENT(aperture) and the general markedness constraint is *STOP, which dislikes stop segments. Given a geminate continuant input, this ranking predicts that the geminate must alter.

(88) *Phonology happens to geminates*

/ifːi/	*GEMCONT	IDENT(ap)	*STOP
a. ifːi	*!		
b. ☞ ipːi		*	*
c. ☞ ifpi		*	*
d. ☞ ipfi		*	*

The faithful candidate (88a) violates the high ranked markedness constraint and is therefore not optimal. The remaining three candidates represent the different alterability options. Each of these candidates violates both IDENT(aperture) and *STOP once. Candidate (88b) violates IDENT(aperture) once and *STOP once because it is a single melody geminates. Since here is only one output segment, there is one violation each of the two constraints. Candidates (88c and d) are both examples of geminate fission. In each case, exactly one segment undergoes a change therefore there is one IDENT(aperture) violation. In addition each fissioned candidate contains one stop consonant, therefore there is one *STOP violation. The question is, why are candidates (b) and (c) possible outcomes of geminate alterability while candidate (d) is not?

The Correspondence theory of faithfulness (McCarthy and Prince 1995) with only general faithfulness coupled with a single melody theory of geminates predicts that all alterability of geminates should be total alterability. For example, consider the same ranking *GemCont » IDENT(aperture), *STOP with the addition of markedness constraints that dislike continuants generally (we can lump these constraints into the single constraint *CONT). With just these constraints and no other constraints in the grammar, fission cannot occur. The tableaux in (89) shows why this is so.

(89) *Alterability is total*

/ifːi/	*GEMCONT	IDENT(ap)	*STOP	*CONT
a. ifːi	*!			*
b. ☞ ipːi		*	*	
c. ipfi		*	*	*!
d. ifpi		*	*	*!

Of the three altered candidates, (89b, c and d), candidates (c) and (d) with fission are harmonically bounded by candidate (b) with total alterability. All three candidates violate IDENT(aperture) and *STOP to the same degree as noted above. Furthermore candidates (c) and (d) also violate *CONT once since they each contain one surface continuant (*f*). However, candidate (b) fairs better than these two on *STOP since it has no output stop. The fissioned candidates (c) and (d) have one more segment and thus fair worse on markedness.

Clearly the only way to rescue the fissioned candidate is through faithfulness. I propose that *onset faithfulness* (Beckman 1997) provides the drive to fission geminates. The tableau in (90) shows how onset faithfulness allows candidate (c) to be optimal with respect to candidate (b) yet still keeps candidate (d) as harmonically bounded.

(90) *Alterability can be total or fission*

/ifːi/	*GEMCONT	IDENT(ap)	*STOP	IDENTONS(ap)	*CONT
a. ifːi	*!				*
b. ☞ ipːi		*	*	*	
c. ☞ ipfi		*	*		*
d. ✘ ifpi		*	*	*!	*

Candidate (90b) with total alterability violates IDENTONS(aperture) because the geminate, parsed as both a coda and an onset, has undergone a featural change. Candidate (90c), with fission, satisfies IDENTONS(aperture) because the faithful portion of the fissioned geminate is parsed in the onset. With IDENTONS(aperture) above *CONTINUANT fission will be preferred over total alterability. The opposite ranking with *CONTINUANT over FAITHONS prefers total alterability. Candidate (90d), the unattested fission case, violates both IDENTONS(aperture) and *CONTINUANT. It is therefore harmonically bounded by both candidate (90b) and candidate (90c), and cannot be optimal.

In the above discussion I have relied on four different constraint types: general markedness constraints, ex. *STOP, *CONT; specific markedness constraints, ex. *GEMCONT; general featural faithfulness constraints, ex. IDENT(aperture); and positional faithfulness constraints, ex. IDENTONS(aperture). Given this constraint set, there are only two possible results for a geminate that is alterable. Either, the entire geminate undergoes the change, total alterability, or the geminate fissions with the onset half of the geminate being unaltered. Each of these two options requires specific rankings between the constraint types.

Total alterability occurs when the positional faithfulness constraint IDENTFEATURE/ONSET is not active on the constraint set. With IDENTFEATURE/ONSET inactive, there is no pressure for the geminate to retain its input specification in the onset and thus force fission. However, when IDENTFEATURE/ONSET is active fission will occur since onset faithfulness pressures the output to preserve part of the geminate in onset. Therefore we can establish the following ranking schema for total alterability and fission of geminates. In both schema, *AXB must dominate FAITHGEN and MARKYGEN since alterability is preferred to inalterability. Total alterability requires that all markedness constraints that dislike the segment X dominate FAITHONS.

(91) *Total alterability ranking schema*

*AXB » FAITHONS, FAITHGEN, MARKYGEN

MARKXGEN » FAITHONS[10]

Both *AXB and MARKXGEN must dominate FAITHONS. That is, in order for geminates to alter completely both the coda half and the onset half of the geminate must be able to undergo featural change. Since total alterability requires that *AXB dominate FAITHONS, only those processes that affect onsets (force violation of FAITHONS) will necessarily totally alter geminates. Geminate fission requires only that FAITHONS dominate MARKXGEN.

(92) *Geminate fission ranking schema*

*AXB » FAITHGEN, MARKYGEN

FAITHONS » MARKXGEN

Fission will be preferred since it preserves onset features even though it increases markedness. The relative ranking between FAITHONS and *AXB is irrelevant. The change in singletons may be restricted to onsets or not. With respect to fission only the onset half of the geminate can be more faithful under the hypothesis that there is no corresponding coda faithfulness. In both cases of alterability the geminate must change due to pressure from the specific markedness constraint. The question is whether the entire geminate will change, thus violating onset faithfulness or whether only part of the geminate will change, thus creating a cluster which increases markedness.

For example, in the geminate hardening case discussed above, the total alterability reranking requires that both *GEMCONT and *CONT must dominate IDENTONSET(aperture).

[10] MARKXGEN » FAITHONS is not required if the *AXB constraint is in a Paninian relationship with FAITHONS.

(93) *Total alterability*

/ifːi/	*GEMCONT	IDENT(ap)	*STOP	*CONT	IDENTONS(ap)
a. ifːi	*!			*	
b. ☞ ipːi		*	*		*
c. ipfi		*	*	*!	

The competition between candidates (a) and (b) shows that *GEMCONT must dominate the general faithfulness constraint IDENT(aperture), the general markedness constraint *STOP, as well as the specific faithfulness constraint IDENTONSET(aperture). The competition between candidates (c) and (b) shows that *CONT must also dominate the specific faithfulness constraint IDENTONSET(aperture). This is the ranking I propose for Fula in section 2.3.1.

The fission ranking requires that IDENTONSET(aperture) be active. In the geminate hardening example this means that it must dominate *CONTINUANT.

(94) *Geminate fission*

/ifːi/	*GEMCONT	IDENT(ap)	*STOP	IDENTONS(ap)	*CONT
a. ifːi	*!				*
b. ipːi		*	*	*!	
c. ☞ ipfi		*	*		*

Again, *GEMCONT must dominate both the general faithfulness constraint IDENT(aperture) and the general markedness constraint *STOP. The competition between candidates (a) and (c) show the need for this ranking. In addition, the competition between candidates (b) and (c) shows that IDENTONSET(aperture) must dominate *CONTINUANT. This is the type of ranking posited for Faroese in section 3.2.

In section two of this chapter I will show how this analysis accounts specifically for cases of total alterability in Faroese, Persian and Fula. In Faroese, palatalization of velar singletons also affects velar geminates, palatalizing them completely. In Persian, hardening of the approximant *υ* in onsets also hardens geminate *υ*. In Fula geminate continuants are hardened to stops. In section three I show how the analysis captures geminate fission in Alabama. In Alabama, voiced geminates are fissioned into nasal, voiced stop clusters. I also argue that Icelandic preaspiration is not geminate fission, but is better understood as the result of a bisegmental analysis of laryngealized stops.

3.2 Full alterability

Full alterability arises when FAITHONSET is inactive in the grammar. Inactivity can arise in two ways. First the markedness constraint driving the phonological change may target onsets. A constraint 'targets' a phonological structure when the constraint applies across the board to that phonological structure. In these situations onset faithfulness must be dominated in order for the markedness constraint to have an effect. Therefore there are no faithfulness constraints which can rescue the other half of the geminate. Palatalizations which target consonants before vowels and onset restrictions are two cases of this sort. I refer to these types of constraints as *right*-edge constraints, since the marked structure occurs at the right edge of the geminate. Constraints where the marked structure is on the left edge of the geminate are *left-edge* constraints.[11]

(95) *Right vs. left edge constraints*

Right edge constraints (*CV, *σ/C): *VELAR-I, *σ/GLIDE

Left edge constraints (*VC, *C:, *μ/C): *I-VELAR, *VOICEDGEMINATE, *μ/STOP

[11] Constraints that target geminates are also defined as left-edge constraints.

The second way of getting FAITHONSET to be inactive requires an emergent ranking (Samek-Lodovici 1997, Bakovic 1998, Nelson 1998). In this type of ranking, a low ranked constraint which is generally violated in the language becomes active through crucial domination by a higher ranked constraint. For example, suppose a general markedness constraint against a segment is dominated by general faithfulness, so you have the ranking FAITH » MARK. Therefore general markedness is inactive in the language. Any attempt to change an input so that it conforms to the markedness constraint is thwarted by the higher ranking faithfulness constraint. In this language the relative ranking between the general markedness constraint and onset faithfulness cannot be determined. For example, assume that the corresponding constraints are IDENT(aperture), *CONTINUANT, and IDENTONSET(aperture). The tableau in (96) shows that the positional faithfulness constraint could be ranked anywhere.

(96) *Position of onset faithfulness is indeterminate*

/ifi/	IDENT(ap)	*CONT	IDENTONS(ap)
a. ☞ ifi		*	
b. ipi	*!		*
/ifti/			
c. ☞ ifti		*	
d. ipti	*!		
/ifːi/			
e. ☞ ifːi		*	
f. ipːi	*!		*
g. ipfi	*!	*	

The tableau considers three separate inputs, an intervocalic singleton, a preconsonantal singleton and a geminate. All three inputs have the faithful candidate as optimal due to ranking the general faithfulness constraint above markedness. The relative ranking of IDENTONSET(aperture) makes no difference to the outcome of these competitions. If it is ranked above IDENT(aperture) or below it, the outcome is the same, the faithful candidate wins.

With this ranking, it appears that the general markedness constraint is inactive. However, if another constraint which marks geminates in the output dominates the general faithfulness constraint, the general markedness constraint gets to become active through the crucial domination of higher ranked general faithfulness. The ranking schema for emergence of a constraint is given in (97).

(97) *Emergence of a general markedness constraint*

*AXB » FAITH » MARKGEN » FAITHONS

If we assume that the specific markedness constraint in (97) is *GEMCONT from above, we get the tableau in (98).

(98) *Emergence of *CONT*

/ifːi/	*GEMCONT	IDENT(ap)	*CONT	IDENTONS(ap)
a. ifːi	*!		*	
b. ☞ ipːi		*		*
c. ipfi		*	*!	

The constraint *GEMCONT crucially dominates IDENT(aperture), forcing its violation. Of the remaining two candidates, one violates *CONTINUANT (candidate c) and the other violates IDENTONSET(aperture) (candidate b). Therefore, if *CONTINUANT can be active if it dominates IDENTONSET(aperture). This is the type of ranking I propose for Fula in section 2.3.1.

The ranking schema in (97) requires an *anti-paninian* ranking (Prince 1997) between general faithfulness and onset faithfulness. Two constraints are in a stringency relation if violation of the special constraint entails violation of the general constraint. FAITHONS is in a stringency relation with FAITHGEN. A violation of FAITHONS (the special constraint) entails a violation of FAITHGEN (the general constraint). An anti-paninian ranking is one in which the general constraint crucially dominates the specific constraint. Anti-Paninian rankings are predicted by free ranking of constraints in Optimality Theory. Beckman (1997) proposes that onset faithfulness always dominates general faithfulness in order to limit the typological predictions of the theory. I argue that rankings like that in (97) do exist, indicating no restrictions on the rankings of onset faithfulness and general faithfulness are required. The emergent ranking of this type is found in Fula geminate hardening.

The ranking in (97) only results in total alterability when the specific markedness constraint at the top of the hierarchy is <u>not</u> in a paninian relationship with FAITHONS. Two constraints are in a paninian relationship (Prince & Smolensky 1993:107) when satisfaction of one constraint entails violation of the other.

(99) *Dfn. Paninian Constraint Relation*

Let S and G be two constraints. *S stands to G as special to general in a Paninian relation* if, for any input i to which S applies non-vacuously, any parse of i which satisfies S fails G.

For example, take the constraint *GEMCONT as the special constraint and IDENTONSET(aperture) as the general constraint. In this case, the two constraints are not in a paninian relationship since it is possible to satisfy both constraints in one candidate. The candidate *ipfi* in tableau (98) does just this.

If the dominant MARKSPEC is a right edge constraint, then it will be in a paninian relationship with FAITHONS. It is impossible to satisfy a right edge constraint in the sequence CV without violating FAITHONS. Assuming it is impossible to parse a pre-vocalic segment as a coda to avoid a FAITHONS violation (see Wilson 1997). Under these circumstances, the ranking in (97) will result in total alterability. The fissioned candidate will violate MARKSPEC. Therefore the relative ranking of MARKGEN and FAITHONSET is irrelevant.

For example suppose we replace the constraint *GEMCONT in the discussion above with the hypothetical right-edge constraint *σ/CONTINUANT, which dislikes continuants parsed as onsets. This new constraint is in a paninian relation with IDENTONSET(aperture) given either an intervocalic or geminate continuant input since IDENTONSET(aperture) must be violated to satisfy *σ/CONTINUANT. The tableau in (100) shows the violation profile given these two inputs.

(100) *Right-edge constraint*

/ifːi/	*σ/Cont	IdentOns(ap)	Ident(ap)	*Cont
a. ifːi	*			*
b. ipːi		*	*	
c. ipfi	*		*	*
/ifi/				
d. ifi	*			*
e. ipi		*	*	

In both candidate sets in (100), the candidates that satisfy *σ/Continuant violate IdentOns(aperture) and vice versa. Therefore, in order for *σ/Continuant to be active, it must dominate IdentOns(aperture). The ranking proposed for Faroese in section 2.1.1 is this type of ranking.

We only find the emergent ranking with left edge *AXB constraints. Left edge markedness constraints do not target onsets; they either target geminates specifically (i.e., *VoicedGeminate or *GeminateContinuant) or target the left edge of the geminate. Therefore they are not in a paninian relationship with FaithOns. Given a geminate input it is possible to satisfy the a left edge constraint and FaithOns at the same time through geminate fission. Total alterability can then only occur when FaithOns is subordinate to general markedness.

3.2.1 Palatalization

Palatalization in Faroese and Luganda affects both singleton segments in onsets and geminates. Since palatalization affects onsets we know that IdentFeature/Ons is subordinate to the markedness constraint driving palatalization. Therefore, palatalization shows total alterability. Here I will give an analysis of Faroese palatalization.

3.2.1.1 Faroese

In Faroese (Petersen, et al. 1998), velar stops become palatal affricates before the front vowels *i* and *e*. Palatalization is allophonic; palatals only occur before *i* and *e*, while velars occur elsewhere. There are several morphological alternations such as the one in (101) that show this distribution.

(101) *Faroese palatalization of singletons*

Inf. Verb	*1sg. Verb*	
va^{h}k - a	va^{h}č - i	'wake'

Palatalization not only affects singletons, but geminates as well. The examples in (102) show the effect of palatalization on geminates.

(102) *Faroese palatalization of geminates*

Sg. Noun	*Pl. Noun*	
vegːur	vějːir	'wall'
be^{h}kːur	be^{h}čːir	No Gloss

Geminate velars are totally alterable in Faroese. Furthermore, palatalization does not fission geminates, *be^{h}kčir.

I propose that the following constraints are involved in palatalization.

(103) *Constraint Set*

IdentPlace	Output segments agree with all their input correspondents for place features.
IdentPlace/Ons	An output segment parsed as an onset agrees with all its input correspondent for place features.
*Palatal	Do not have palatal segments.
*Velar	Do not have velar segments.
*Velar-I	Do not have a velar followed by a front high/mid vowel.

There are two faithfulness constraints the general IdentPlace and the specific IdentPlace/Ons. The two general markedness constraints, *Palatal and *Velar represent the markedness of segments of these types. Finally, the specific markedness constraint *Velar-I drives the palatalization.

The constraints in (103) have the partial ranking in (104) for Faroese.

(104) *Faroese ranking*

*Velar-I » *Palatal » IdentPlace, IdentPlace/Ons, *Velar

Velars are the default for back consonants since *Palatal dominates both faithfulness constraints and *Velar. The markedness constraint *Velar-I targets onsets since they are included in its structural description. Furthermore, IdentPlace/Ons is subordinate to *Velar-I indicating that onsets will undergo palatalization.

The tableaux in (105) and (106) show how this ranking results in the neutralization of underlying velars and palatals to surface velars.

(105) *Velars are default, from* /va^{h}ka/

/va^{h}ka/	*Velar-I	*Pal	IdentPlace	IdentPlace/Ons	*Vel
a. va^{h}ča		*!	*	*	
b. ☞ va^{h}ka					*

(106) *Velars are default, from* /va^{h}ča/

/va^{h}ča/	*Velar-I	*Pal	IdentPlace	IdentPlace/Ons	*Vel
a. va^{h}ča		*!			
b. ☞ va^{h}ka			*	*	*

In non-palatalizing environments palatals and velars neutralize to velars. Therefore *Palatal must dominate both faithfulness constraints and *Velar.

The markedness constraint *Velar-I militates against a velar before

front vowels. Since it is ranked above *Palatal, *Velar-I can force the change to a palatal segment. Also, since it was already established that *Palatal dominates IdentPlace and IdentPlace/Ons, by transitivity *Velar-I also dominates these two constraints. The tableaux in (107) and (108) show the result of this ranking given a velar and palatal input respectively.

(107) *Palatalization, from* /va^{h}ki/

/va^{h}ki/	*Velar-I	*Pal	IdentPlace	IdentPlace/Ons	*Vel
a. ☞ va^{h}či		*	*	*	
b. va^{h}ki	*!				*

(108) *Palatalization, from* /va^{h}či/

/va^{h}či/	*Velar-I	*Pal	IdentPlace	IdentPlace/Ons	*Vel
a. ☞ va^{h}či		*			
b. va^{h}ki	*!		*	*	*

*Velar-I must dominate *Palatal and by transitivity both faithfulness constraints since it can create a surface palatal.

The top two constraints determine the distribution of palatals and velars in Faroese on markedness grounds only. The lower ranked constraints, IdentPlace, IdentPlace/Ons and *Vel cannot be ranked with respect to one another since all decisions are made by *Velar-I and *Palatal. That is, velars and palatals are in complementary distribution in Faroese.

Because of the relative high ranking of the markedness constraints *Velar-I and *Palatal total alterability is the only possible outcome for geminates. The tableau in (109) shows that inalterability and coda fission are ruled out by *Velar-I over *Palatal.

(109) *Total alterability from* /be^{h}k:ir/

/be^{h}k:ir/	*VELAR-I	*PAL	IDENTPLACE	IDENTPLACE/ONS	*VEL
a. ☞ be^{h}č:ir		*	*	*	
b. be^{h}čkir	*!	*	*		*
c. be^{h}k:ir	*!				*

The tableau in (109) compares three candidates. Candidate (a) totally alters the geminate. Candidate (b) is a fissioned geminate where the faithful half of the geminate is in the onset position. Candidate (c) is the candidate where the geminate has failed to alter (inalterability). Both candidates (b) and (c) are ruled out by this ranking. Candidate (b) violates the specific markedness constraint *VELAR-I. Since we know from above that *VELAR-I must dominate *PALATAL and the two faithfulness constraints, the violation of *VELAR-I is fatal. Candidate (c) also violates *VELAR-I. In order for either candidate (b) or (c) to be optimal, IDENTPLACE/ONS would need to dominate *VELAR-I. However, ranking IDENTPLACE/ONS above *VELAR-I would result in the language not having palatalization with singleton segments or geminates.

The totally altered candidate also wins over the onset fissioned candidate. In fact the onset fissioned candidate cannot be optimal under any ranking as the tableau in (110) shows.

(110) *Total alterability from* /be^{h}k:ir/

/be^{h}k:ir/	*VELAR-I	*PAL	IDENTPLACE	IDENTPLACE/ONS	*VEL
a. ☞ be^{h}č:ir		*	*	*	
b. ✘ be^{h}kčir		*	*	*	*!

Candidate (b) where the faithful half of the geminate is in the coda is harmonically bounded by candidate (a). It has an extra velar segment violating markedness with no corresponding improvement on faithfulness. Therefore candidate (b) is ruled out universally. Total alterability of geminates is the only possible outcome of these constraints with this ranking.

An input pair geminate neutralizes in Faroese to a singleton segment even in the palatalization environment. The tableau in (111) shows this result.

(111) *Neutralization of pair geminate from* /be^{h}k$_1$k$_2$ir/

/be^{h}k$_1$k$_2$ir/	*VELAR-I	*PAL	IDENTPLACE	IDENTPLACE/ONS	*VEL
a. ☞ be^{h}č$_{1,2}$ir		*	*	*	
b. be^{h}k$_1$č$_2$ir		*	*	*	*!

Both candidates tie on *VELAR-I, *PALATAL, IDENTPLACE and IDENTPLACE/ONS. Therefore candidate (b) loses out on *VELAR, by virtue of having an extra velar segment. As I have shown in Chapter two, pair geminates cannot contrast with singletons or geminates.

The discussion of Faroese shows that total alterability occurs when IDENTPLACE/ONS is inactive. Because the markedness constraint driving palatalization is a right edge constraint, it targets onsets and therefore must dominate IDENTFEATURE/ONSET to be active. Total alterability of geminates is the necessary result. Fission is impossible with right edge constraints since fission requires IDENTF/ONS to be active.

3.2.2 Onset restrictions

Onset restrictions are another case where the only result is total alterability. Inkelas and Cho (1993) claim that geminates always obey onset restrictions. For example in Korean, the velar nasal *ŋ* can only appear in codas, not in onsets.

(112) *Korean onset restriction* (Inkelas & Cho 1993; 537)

a. kaŋ ‘river’

b. maŋcʰi ‘hammer’

c. *ŋa

The banning of ŋ from onsets extends to geminates.

(113) *Korean geminate restriction* (Inkelas & Cho 1993; 537)

a. ənni ‘older sister’

b. əmma ‘mom’

c. *aŋŋa

Inkelas and Cho argue that the ban on ŋ in onsets is due to an onset specific constraint. Furthermore, such onset specific constraints are universally obeyed by geminates.

In the OT system proposed here, this universal claim follows. If an onset specific constraint is enforced through featural change this necessarily entails that IDENTFEATURE/ONSET must be subordinate to a markedness constraint. Since this is the case, geminates must show total alterability.[12] Persian *v*-weakening is case of such an onset restriction which leads to geminate total alterability.

3.2.2.1 Persian

Hayes (1986) argues that Persian is an example of geminate inalterability. However, I argue here that is better understood in terms of geminate alterability. In Persian (Cowan and Yarmohammadi 1978, Hayes 1986), the labiodental fricative (*v*) is in complementary distribution with the labiodental approximant (*ʋ*)).

[12] This claim holds as long as there aren’t complementary restrictions on what can be moraic that could block a geminate from hardening.

(114) *The distribution of v and ʋ in Persian*

a. ʋ *after short vowels*

pa:ltoʋ	‘overcoat’	moʋ	‘vine’
četoʋr	‘how’	doʋre	‘era’

b. v *initially, after consonants, and after long vowels*

væli:	‘but’	voǰu:d	‘existence’
kešvær	‘country’	omi:dva:r	‘hopeful’
ga:v	‘bull’	hi:vdæh	‘seventeen’
ǰozv	‘except’	særv	‘cypress’

The examples in (114) show that *v* and *ʋ* are in complementary distribution in Persian. The segment *ʋ* occurs only in codas following short vowels. Elsewhere *v* occurs. The examples in (115) show that morphological alternations exist which confirms relating the two segments allophonically.

(115) *Morphological alternations*

a. mi:rævæm ‘I am going’

boroʋ ‘go!’

b. noʋru:z (< /nov ru:z/) ‘New Year’

novi:n ‘new kind’

c. mi:dævi:d ‘you are running’

pa:doʋ (< /pa: dæv/) ‘gofer’

The examples in (116) illustrate that *v* can occur geminated.

(116) *Geminate v's*

a. ævvæl 'first'

b. morovvæt 'generosity'

c. qolovv 'exaggeration'

Hayes (1986), following Cowan and Yarmohammadi (1978) analyzes this as weakening of *v* in codas. Seen this way, it is curious that geminates do not weaken since they are in codas.[13] However, I propose that in Persian *ʋ* only occurs in moraic positions, elsewhere it is hardened to *v*. Seen in this light, geminates are subject to hardening as are onsets. Persian *v*-weakening is a case of geminate alterability.

My analysis follows from the constraint set in (117) and the ranking in (118).

(117) *Constraint Set*

IDENTAP	Output segments agree in aperture specifications with all their input correspondents.
IDENT-ONSETAP	An output segment parsed as an onset agrees in aperture specifications with all its input correspondents.
*σ/GLIDE	No approximants associated directly to syllables (in non-moraic positions).
*V	No v.
*GLIDE	No approximant segments.

The constraints IDENTAP is a faithfulness constraint (McCarthy and Prince 1995). It is violated when any change in the aperture specification from input to output occurs. Its more specific partner IDENT-ONSETAP is the same

[13] Kirchner (1998a, b) following Churma (1988) claims that geminates are never subject to weakening processes. If this is true then we can subsume Persian *v*-weakening to a case of geminate inalterability.

constraint restricted to onsets. It is violated when the aperture specification is changed from input to output and the output segment is parsed as an onset. The other three constraints are markedness constraints. The constraints *V and *GLIDE are the general markedness constraints against segments of these types. *V is violated when the output contains the segment v. *GLIDE is violated when the output contains the segment *ʋ*. The constraint *σ/GLIDE from Prince and Smolensky (1993) (See also Rosenthall 1994) is a context specific markedness constraint. It is violated when a glide is parsed in a margin position, not as a moraic segment.

In addition to these constraints, I will assume that both moraic and non-moraic codas are possible in Persian. I assume that syllables are maximally bi-moraic and that coda consonants are moraic when the bi-moraic restriction is not violated. That is a coda consonant following a short vowel is moraic, but a coda consonant following a long vowel or another coda consonant is not moraic.

I assume that *ʋ* is the default segment. This means that *GLIDE is the lowest ranked of the two general markedness constraints[14] and that *V dominates IDENTAP. The default mapping (v, ʋ ↦ ʋ) is blocked when the segment is parsed as an onset. In this case, the mapping goes to v (v, ʋ ↦ v). This mapping reflects the ranking of the specific markedness constraint *σ/GLIDE above the default mapping ranking. The full ranking in (118) shows these relative rankings.

(118) *Ranking in Persian*

*σ/GLIDE » *V » IDENTAP, IDENT-ONSETAP, *GLIDE

Since *V dominates IDENTAP which dominates *GLIDE, the default

See chapter four for discussion of geminate inalterability.

[14] There do not seem to be any markedness considerations that would argue for a universal ranking between the two general markedness constraints.

consonant is the glide. The positional markedness constraint *σ/GLIDE forces hardening in onsets by dominating *V.

The tableaux in (119) and (120) show that in the moraic position input *v* and *ʋ* neutralize to *ʋ*.

(119) *Codas neutralize*

/borov/	*σ/GLIDE	*V	IDENTAP	IDENT-ONSETAP	*GLIDE
a. ☞ borou			*		*
b. borov		*!			

(120) *Codas neutralize*

/borou/	*σ/GLIDE	*V	IDENTAP	IDENT-ONSETAP	*GLIDE
a. ☞ borou					*
b. borov		*!	*		

In this case, the segment under consideration is parsed as a moraic coda. Therefore the constraint *σ/GLIDE is irrelevant. In both tableaux the (b) candidate violates *V. In tableau (119) the (a) candidate violates IDENTAP and *GLIDE. Therefore *V must dominate these two constraints. This domination relation also accounts for the mapping in tableau (120). Regardless of the input, moraic labiodental surface as approximants.

The tableaux (121) and (122) show that in onsets, *ʋ*s harden to *v*s.

(121) *Hardening in onsets*

/ǰæviːn/	*σ/GLIDE	*V	IDENTAP	IDENT-ONSETAP	*GLIDE
a. ☞ ǰæviːn		*			
b. ǰæʋiːn	*!		*	*	*

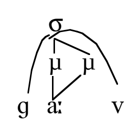
(122) *Hardening in onsets*

/ǰæʋiːn/	*σ/GLIDE	*V	IDENTAP	IDENT-ONSETAP	*GLIDE
a. ☞ ǰæviːn		*	*	*	
b. ǰæʋiːn	*!				*

In this case, the segment is parsed as an onset. Therefore the constraint *σ/GLIDE is active. It must dominate *V in order to force hardening. Here again markedness rules the day. The input is irrelevant, i.e. no contrast between v and ʋ is savable. Crucially, Tableau (121) shows that IDENT-ONSETAP must be dominated by *σ/GLIDE. If IDENT-ONSETAP dominated *σ/GLIDE, candidate (b) would be optimal in tableau (121). The result would be that *ʋ* and *v* would contrast in onsets.

In addition to hardening in onsets, the approximant *ʋ* also hardens after long vowels and when it is the second member of a complex coda. I propose that these positions are non-moraic. In (123) I show the structure I assume for the form *gaːv* 'bull'.

(123) *Non-moraic codas*



Since these coda positions are non-moraic, a glide parsed there violates the constraint *σ/GLIDE. Therefore hardening occurs here as well as in onsets.

(124) *Hardening in non-moraic codas*

/gaːv/	*σ/GLIDE	*V	IDENTAP	IDENT-ONSETAP	*GLIDE
a. ☞ gaːv		*			
b. gaːʋ	*!		*	*	*

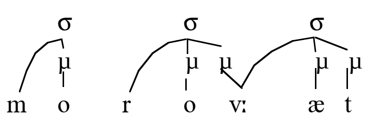
(125) *Hardening in non-moraic codas*

/gaːʋ/	*σ/GLIDE	*V	IDENTAP	IDENT-ONSETAP	*GLIDE
a. ☞ gaːv		*	*	*	
b. gaːʋ	*!				*

Candidate (a), with hardening of the glide, is optimal in both tableau because of the high ranking of *σ/GLIDE.

The same constraint ranking also causes hardening with geminates, which are treated as a subclass of onsets.

(126) *Geminates*



The geminate *vː* in *morovːæt* is linked to both the coda of a syllable and the onset of a syllable. Any geminate approximant will violate the *σ/GLIDE constraint. The tableaux (127) and (128) show this outcome.

(127) *Hardening with geminates*

/morovːæt/	*σ/GLIDE	*V	IDENTAP	IDENT-ONSETAP	*GLIDE
a. ☞ morovːæt		*			
b. moroʋvæt		*	*!		*!
c. morovʋæt	*!	*	*	*	*
d. moroʋːæt	*!		*		

(128) *Hardening with geminates*

/moroʋːæt/	*σ/GLIDE	*V	IDENTAP	IDENT-ONSETAP	*GLIDE
a. ☞ morovːæt		*	*	*	
b. moroʋvæt		*	*	*	*!
c. morovʋæt	*!	*	*		
d. moroʋːæt	*!				

Candidates (c and d) are ruled out in both tableaux since they violate the highest ranked constraint *σ/GLIDE. The remaining two candidates tie on *V since they both contain one instance of *v*. In each case, fission (candidates b and c) is either harmonically bounded by the total alterability candidate (a) or ruled out by the higher ranking specific markedness constraint. These tableaux show that since hardening occurs in onsets, it is also occurs with geminates.

In conclusion, we see that constraints that make specific reference to onsets, are a special case of the right-edge constraints. If these constraints dominate a faithfulness constraint in some language, effectively banning certain segments from onset positions, then they also ban geminate segments of that type.

3.2.3 Geminate Targeting - total alterability

In languages like Fula, Faroese and Tümpisa Shoshone geminates are singled out as targets for phonological processes. This indicates that markedness constraints can be sensitive to geminates in particular. Geminate targeting constraints are not like the right-edge constraints looked at in sections 2.1 and 2.2. Rather they can be satisfied by either total altering of the geminate or fission. Therefore these constraints are classified as left-edge constraints.

In Fula geminate continuants are dispreferred and harden to geminate stops. The result of geminate hardening is total alterability, not fission. Since the markedness constraint driving hardening is a left-edge constraint, total alterability must result from the anti-paninian ranking of general faithfulness over specific faithfulness described above.

3.2.3.1 Fula

Fula (Paradis 1992) has the following phonemic consonants.

(129) *Fula consonants*

	Labial		Dental		Palatal		Velar		Glottal
Stops	p	b	t	d	c	j	k	g	
Implosives		ɓ		ɗ		ʄ		ɠ	
Nasals		m		n		ɲ		ŋ	
Fricatives	f		s						
Liquids				r					
				l					
Glides	w					y			h

Fula also has geminate consonants. However, there are no geminate continuants in the language. That is the following geminates are not allowed in the language: *ff, *ss,*hh, *ww, *yy, *rr. Geminate stops, implosives and

nasals do occur in the language. Furthermore, when a continuant becomes geminated through a morphological process, the continuant hardens (Paradis 1988 refers to these as occlusivized continuants). The following mappings hold in Fula.

(130) *Geminate hardening in Fula*

/ff/ → pp, /ss/ → cc, /hh/ → kk, /ww/ → bb, /yy/ → jj, /rr/ → dd

The hardening mapping is shown by the examples in (131) where a morphological alternation occurs.

(131) *Fula geminating morphology*[15]

	Stems	Various M	Occlusivization	Gloss
ww → bb				
a.	saw	sawru	cabbi	'stick'
b.	lɛw	lɛwru	lɛbbi	'month'
c.	fɔw	fowru	pobbi	'hyena'
d.	ɲɛw	ɲɛwru	ɲɛbbi	'bean'
yy → jj				
e.	wuy	wuyɓɛ	gujji	'thief'
ff → pp				
f.	lɛf	lɛfol	leppi	'ribbon'
g.	hɔf	hofru	koppi	'knee'
h.	nɔf	nofru	noppi	'ear'
i.	sɔf	sɔfru	coppi	'chick'

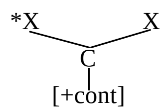
[15] In these examples, the initial continuants also harden.

ss → cc

j.	kɔs	kɔsam	kɔccɛ	'curdled milk'

The examples in (131) show that some suffixes cause gemination of the stem final consonant with subsequent occlusivization. Paradis (1988) proposes a configurational constraint against geminate continuants to account for both the lack of these geminates in Fula and the occlusivization of continuants when morphologically geminated. She states this constraint as in (132).

(132) Constraint on Continuant Geminates (*GEMCONT) (Paradis 1992)



In the constraint in (132) the Xs represent timing units which for Paradis are skeletal slots.[16] Bakovic (1995) proposes an OT account of the Fula data in which the constraint *GEMCONT dominates PARSE(Cont), or in our terms IDENTAP.

(133) *GEMCONT No Geminate continuants. Bakovic (1995)

This constraint dominates IDENTAP in Fula, causing hardening. In addition IDENT-ONSETAP must be subordinate to *F to avoid fissioning of the geminate.

(134) *Fula ranking*

*GEMCONT » IDENTAP » *B,*F

*F » IDENT-ONSETAP

Under this ranking geminate continuants cannot surface. The ranking in (134) is anti-paninian since IDENTAP » *F » IDENT-ONSETAP.

Fula has both singleton stops and singleton continuants. Therefore the general markedness constraints against stops and fricative must both be

[16] This constraint gains typological support from the survey of languages with geminates in Ruhlen (1976). Many languages in the survey which have geminates do not have geminate continuants.

dominated by IDENTAP.

(135) *IDENTAP dominates *B and *F*

/…f…/	IDENTAP	*B	*F
a. ☞ …f…			*
b. …p…	*!	*	
/…p…/			
a. …f…	*!		*
b. ☞ …p…		*	

Since input *f*s surface as *f* generally, the markedness constraint *F cannot dominate IDENTAP. A similar argument is made for the relation between IDENTAP and *B. Since input *p*s do not weaken to spirants, IDENTAP must dominate *B.[17] Since the distribution of stops and continuants is quite general, the relative ranking of IDENT-ONSETAP cannot be determined by these inputs.

The fact that geminates harden indicates that *GEMCONT must dominate IDENTAP, IDENT-ONSETAP and *B.

(136) **GEMCONT dominates IDENTAP, IDENT-ONSETAP, and *B*

/caf + ᵘi/	*GEMCONT	IDENTAP	*B	IDENT-ONSETAP	*F
a. ☞ cabbi		*	*	*	
b. caffi	*!				*

The unaltered candidate, (b), loses on *GEMCONT. This constraint must dominate IDENTAP, IDENT-ONSETAP, and *B since the winning candidate (a) violates these three constraints.

The comparison between the total alterability candidate and the fissioned candidate shows that IDENT-ONSETAP must be subordinate to *F.

[17] The relative ranking between *B and *F is not relevant here, though on markedness grounds we could posit that *F dominates *B universally.

(137) *Anti-Paninian ranking*

/caf + ^{h}i/	*GEMCONT	IDENTAP	*B	*F	IDENT-ONSETAP
a. ☞ cabbi		*	*		*
b. cabfi		*	*	*!	

Candidate (b), the fission candidate, violates *F, while the winning candidate does not. Therefore, *F must dominate IDENT-ONSETAP. With non-geminate inputs, this ranking has no effect since IDENTAP dominates *F. It is only when IDENTAP is inactive through crucial domination by *GEMCONT that this ranking decides. The ranking of these constraints is anti-paninian since IDENTAP dominates *F which dominates IDENT-ONSETAP. By transitivity IDENTAP dominates IDENT-ONSETAP.

One typological prediction made by this analysis is that IDENTONS could be ranked above general markedness. In this situation fission will occur with geminates. Faroese Verschärfung is this type of hardening I will discuss that case in section 3.2.

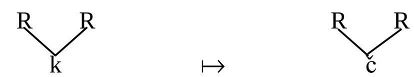
3.2.4 The Two Root theory

As I mentioned in chapter two, there are two proposals for the representation of single melody geminates, the moraic representation (Hayes 1986, McCarthy & Prince 1986) and the Two-Root representation (Selkirk 1990). In this section I will look at how a Two-Root representation can handle total alterability, particularly the Faroese facts. I conclude that with respect to total alterability, the two representations make generally the same predictions.

I will assume the same constraints and rankings for Faroese as (104) above. What does this system do with a Two-Root input? In order to answer that question we must settle the issue of how the IDENT(F) constraints evaluate the total alterability candidate.

In the mapping from an underlying two root geminate to a surface two root altered geminate in (138), only one melody has changed, but two root nodes have changed.

(138) *Two root node change*



The number of IDENT(F) violations calculated in (138) depends on what we take to be the domain of IDENT(F). If the root nodes in (138) are in correspondence then we assess two IDENTPLACE violations, one for each root node. If the melodies in (138) are in correspondence we assess one IDENTPLACE violation.

Which option we choose is crucial to the outcome. If we assume that the root nodes are in correspondence, then we make the wrong prediction. In addition we need *VELAR to dominate IDENTPLACE. The tableau in (139) shows the result.

(139) *Root node correspondence with* /be^{h}k$_1$k$_2$ir/

/be^{h}k$_1$k$_2$ir/	*VELAR-I	*PAL	*VEL	IDENTPLACE	IDENTPLACE/ONS
a. ☞ be^{h}č$_{1,2}$ir		*		**	*
b. be^{h}k$_1$č$_2$ir		*	*!	*	*

Candidates (a) and (b) differ on *VELAR and IDENTPLACE violations. Candidate (a) has two IDENTPLACE violations since the two root geminate has been totally changed. Candidate (b) avoids one IDENTPLACE violation through fission. However, candidate (b) incurs a *VELAR violation. Therefore in order for candidate (a) to win, *VELAR must dominate IDENTPLACE.

Although this ranking appears to be a mark against the Two Root representation, it is not necessarily problematic. We could introduce a new constraint (for example, NOFISSION which dislikes geminate fission) to rule out candidate (b). The real problem with this analysis is that candidate (b) is not harmonically bounded, so that reranking of constraints can make (b) optimal. Fission in this manner never happens.

If we assume that the melodies are in correspondence, then the Two Root theory is the same as the Moraic Theory.

(140) *Melody correspondence with* /be^{h}k$_1$k$_2$ir/

/be^{h}k$_1$k$_2$ir/	*VELAR-I	*PAL	*VEL	IDENTPLACE	IDENTPLACE/ONS
a. ☞ be^{h}č$_{1,2}$ir		*		*	*
b. be^{h}k$_1$č$_2$ir		*	*!	*	*

Just as in the Moraic theory, candidate (b) is harmonically bounded by candidate (a) and no further ranking of the three lowest constraints is required. The crucial difference between the Moraic Theory and the Two Root Theory is that the Two Root Theory posits an extra layer of prosodic structure. Barring any need for the extra layer I will assume the simpler Moraic Theory.

3.2.5 Conclusion

In this section I have shown that whenever onset faithfulness is inactive, total alterability of geminates results. This occurs in two types of rankings. In the first ranking type the specific markedness constraint is a right edge constraint which targets onset segments. Therefore in order for this markedness constraint to be active it must dominate onset faithfulness. Since this ranking is given, total alterability of geminates follows. Reranking of onset faithfulness above specific markedness blocks the process from applying in the language generally. In the second ranking type the onset faithfulness constraint is ranked lower than the general markedness constraints. This ranking is anti-paninian with respect to general faithfulness and onset faithfulness. The reverse ranking, when onset faithfulness is active on the candidate set, results in fission rather than total alterability. That ranking is the subject of the next section.

3.3 Fission

Geminate fission is the splitting of an underlying single melody geminate into two surface segments. For example, in Alabama a geminate *b* is split into a nasal and a voiced stop, i.e., *mb*. In (141) I present a survey of cases of geminate fission.

(141) *Survey of geminate fission cases*

Language	**Change**	**Source**
Alabama	bb ↦ mb	Hardy & Montler (1988)
Japanese	bb ↦ mb	
	dd ↦ nd	
	gg ↦ ŋg	McCawley (1968)
Chimacuro	ll ↦ ɬl	Parker (1992)
Dominican/ Puerto Rican Spanish	rr ↦ hṛ	Cedeño (1994)
Faroese	ww ↦ kv	Anderson (1972)
Icelandic	ll ↦ dl	Chapman (1962)
Icelandic/ Western Norwegian dialects	nn ↦ dn	Chapman (1962)
Western Norwegian dialects	mm ↦ bm	Chapman (1962)

As I discussed above, no language fissions a geminate where the second half of the geminate changes while the first half does not, i.e. **bb* ↦ *bm*.

I propose that geminate fission is the result of an active onset faithfulness constraint. Onset faithfulness can be active in two ways. Onset faithfulness may dominate the specific markedness constraint that is marking the geminate output. An example of this type of ranking is the analysis of coda nasalization in Alabama. These rankings are always neutralizations. When onset faith is the highest ranked constraint contrasts are maintained in onsets, but can be neutralized in codas. A second way that onset faithfulness can be inactive is if it does not necessarily conflict with the specific markedness constraint that is pressuring geminates to change. For example, the geminate specific constraint *GEMCONT in the analysis of Fula above does not necessarily conflict with IDENT(F)/ONS. My analysis of Faroese Verschärfung rests on the lack of conflict between these two constraints.

3.3.1 Alabama nasalization

‘Oh Alabama the devil fools with the best laid plans’
-Alabama
Neil Young

Alabama is an Eastern Muskogean language. It has the following inventory.

(142) *Alabama phonemic inventory*

	Labial	Dental	Palatal	Velar	Glottal
Stops voiced		t		k	
voiceless	b				
Nasals	m	n		ŋ	
Fricatives	f	s	c		
Liquids		l	ɬ		
Glides	w		y		h

The only voiced stop is *b*. All other stops are either voiceless or nasal. In

Alabama (Hardy and Montler 1988; Sylestine, Hardy and Montler 1993), there is no b in codas on the surface. Hardy and Montler (1988) propose that underlying *b* surfaces as *m* in codas.

There is a morphological process that shows the b/m alternation. Alabama forms the plural of certain verbs by deleting a part of the stem, generally a VC sequence. This process is referred to as the disfix plural (Hardy and Montler 1988). A disfix plural can cause a *b* to be parsed into coda where it surfaces as *m*, as shown in (143).

(143) *Stem*	*Disfix plural*	*Gloss*
ɬobafka	ɬomka[18]	‘to have a hole’

The disfix plural deletes the *af* sequence from the verb, causing the *b* which is an onset in *ɬobafka* to be parsed as a coda. In the coda the *b* is realized as *m*.

The change from *b* to *m* in codas also fissions geminate *b*. Alabama also has a morphological process which geminates stem consonants to mark an aspectual change on verbs (Hardy and Montler 1988, Samek-Lodovici 1993).

(144) *Verb*	*Aspectual form*	*Gloss*
balaaka	bállaaka	‘lie down’
cokooli	cókkooli	‘sit down’
ilkowatli	ilkówwatli	‘move’

Gemination occurs on the consonant following the pitch accent that is

[18] Surface *m* derived from *b* does not assimilate in place to a following stop. However, underlying nasals do assimilate.

associated with the morpheme. When this consonant is a *b* in the unaffixed stem it does not geminate.

(145)

Verb	*Aspectual form*	*Gloss*
tabatka	támbatka	'grab'
sobayli	sómbayli	'know, learn'
abanni	ámbanni	'cross'
tobaaci	(ilii-)tómbaaci	'make something'

As (145) shows, a geminated *b* surfaces as *mb*, not as a long *b*.

I propose that the following constraints account for the coda neutralization of *b* to *m* as well as the fission of geminate *b*.

(146) *Constraint Set*

IDENT(nasal)	Output segments have the same values for [nasal] as all their input correspondents. Let $y \in S_2$. For all $x \in S_1$ where $x \Re y$, if y is [γnasal] then x is [γnasal].
IDENT-ONSET(nasal)	Output segments parsed in the onset have identical values for [nasal] as all their input correspondents. Let $y \in S_2$ parsed as an onset. For all $x \in S_1$ where $x \Re y$, if y is [γnasal] then x is [γnasal].
MAXμ	Do not delete moras
*NASAL	Do not have [+nasal] segments.
*VOICEDSTOP	Do not have [-cont, +voice] segments.

*V-VOICEDSTOP(*VC) Do not have a vowel followed by a [-cont, +voice] segment.

The constraint set in (146) consists of three faithfulness constraints and three markedness constraints. IDENT(nasal) is the general faithfulness constraint which bans changing nasality of segments. IDENT-ONSET(nasal) is the positional faithfulness version of IDENT(nasal). MAX-μ is a prosodic faithfulness constraint that militates against deleting input moras in the output. *NASAL and *VOICEDSTOP are the two general markedness constraints against nasal and voiced stop segments respectively. In the analysis here, these two constraints also represent any constraint that may dislike a surface nasal or voiced stop. The specific markedness constraint *V-VOICEDSTOP militates against having a voiced stop post vocalically. I propose that this constraint is responsible for the change of *b* to *m* in codas and the fissioning of geminate *b*.

It may be that the constraint *V-VOICEDSTOP is better understood as a constraint targeting voiced geminates. However, I will assume this more general constraint for two reasons. First, the general formulation of *V-VOICEDSTOP ties the coda nasalization of singleton *b* together with the fissioning of geminate *b*. The two cases of this type of fission I have found, Japanese and Alabama also have singletons neutralizing to nasals in codas. Also, as formulated here V-VOICEDSTOP is a left-edge constraint. In Chapter five I will explore the typological consequences of left-edge constraints.

In addition to the constraints in (146), I will assume that voiced stops are universally more marked than nasals.

(147) *Universal Ranking*

*VOICEDSTOP » *NASAL

This assumption is supported by the fact that many languages have nasals but not voiced stops (Ruhlen 1976).

In Alabama, *b* and *m* contrast in onsets. Following Beckman (1997), I propose that IDENT-ONSET(nasal) prevents voiced stops from neutralizing to nasals in onsets.

(148) *Voiced stops retained in onset*

IDENTONS(nas) » *VC, *VOICEDSTOP » *NASAL

Since IDENT-ONSET(nasal) dominates all the markedness constraints against voiced stops and nasals, the language cannot neutralize *b* to *m* in onsets. Tableau (149) shows that an input intervocalic *b* surfaces faithfully under this ranking.

(149) *Onset* b *does not neutralize*

/CVbV/	IDENTONS(nas)	*VC	*VOICED STOP	*NAS
a. .CV.mV.	*!			*
b. ☞ .CV.bV.		*	*	

Despite the markedness of the post-vocalic *b* in candidate (b), it violates both *V-VOICEDSTOP and *VOICEDSTOP, this candidate is optimal. Altering the *b* to an *m* violates the higher ranked IDENT-ONSET(nasal).

Alabama neutralizes any coda *b* to *m*. Under the ranking proposed here, coda voiced stops neutralize to nasals due to inactivity of IDENTONS(nas).

(150) *Codas Neutralize*

/CVbCV/	IDENTONS(nas)	*VC	*VOICEDSTOP	IDENT(nas)	*NAS
a. ☞ CVmCV				*	*
b. CVbCV		*!	*!		

The two markedness constraints, *V-VOICEDSTOP and *VOICEDSTOP, both prefer the nasal coda to the voiced stop coda. Since both candidates satisfy Ident-Onset(nasal), the altered candidate (a) is optimal.

The relative high ranking of *V-VOICEDSTOP and IDENTONS(nas) in Alabama also forces geminates to fission. *V-VOICEDSTOP dominates IDENT(nasal) in Alabama. This ranking, in combination with the ranking of IDENT-ONSET(nasal) above *V-VOICEDSTOP forces fission of geminates.

(151) *Geminate voiced stops fission*

IDENT-ONSET(nasal) » *VC » IDENT(nas)

Fission of a geminate *b* allows you to satisfy both IDENT-ONSET(nasal) and *V-VOICEDSTOP.

Tableaux (152) shows how these constraints prefer fission to total alterability.

(152) *Fission of geminates*

/CVb^{μ}V/	IDENTONS(Nas)	*VC	*VOICEDSTOP	IDENT(nas)	*NAS
a. [CVm^{μ} V]	*!			*	*
b. ☞ [CVmbV			*	*	*

Candidates (a) and (b) conflict on IDENT-ONSET(nasal) and *VOICEDSTOP. Candidate (a) violates IDENT-ONSET(nasal) while candidate (b) satisfies IDENT-ONSET(nasal). Candidate (b) on the other hand violates *VOICEDSTOP while candidate (a) satisfies that constraint. Since candidate (b) is optimal, IDENT-ONSET(nasal) must dominate *VOICEDSTOP.

Tableaux (153) shows how these constraints prefer fission to inalterability.

(153) *Fission of geminates*

/CVb^{μ}V/	IDENTONS(Nas)	*VC	*VOICEDSTOP	IDENT(nas)	*NAS
a. [CVb^{μ} V]		*!	*		
b. ☞ [CVmbV			*	*	*

Candidates (a) and (b) disagree on *V-VOICEDSTOP, IDENT(nasal) and *NASAL. Candidate (a) avoids both the IDENT(nasal) and *NASAL violations by being totally faithful to the geminate *b* input. However, it does so at the expense of a *V-VOICEDSTOP violation. Candidate (b) on the other hand satisfies *V-VOICEDSTOP but violates both IDENT(nasal) and *NASAL since part of the input geminate *b* has changed to an *m*. Since candidate (b) is the optimal candidate, *V-VOICEDSTOP must dominate IDENT(nasal) and *NASAL.

To prevent degemination, the faithfulness constraint MAXμ must dominate IDENT(nasal) and *NASAL.

(154) *No degemination*

/CVb^μV/	MAXμ	*VOICEDSTOP	IDENT(nas)	*NAS
a. [CVbV]	*!	*		
b. ☞ [CVmbV]		*	*	*

Candidate (a), with degemination, avoids the IDENT(nasal) and *NASAL violations by not parsing the segment as a geminate. Therefore MAXμ must dominate IDENT(nasal) and *NASAL to avoid degemination.

An important question is whether we need *both* contextual faithfulness, IDENT-ONSET(nasal), and contextual markedness, *V-VOICEDSTOP, to get fission. The answer to that question is, yes. Both types of constraints are required in order for fission to be the optimal outcome. I will show that fission is impossible if we assume just contextual markedness or just contextual faithfulness.

Fission is impossible in a grammar with just contextual markedness. Suppose for example we use a contextual markedness like constraint *μ/VOICESTOP in our analysis of Alabama.[19]

(155) *Contextual markedness constraint*

*μ/VOICESTOP Do not have a voiced stop parsed in a coda.

To account for the general pattern in Alabama, *μ/VOICESTOP would have to dominate IDENT(nasal), which in turn dominates *VOICEDSTOP and *NASAL. With this ranking, voiced stops and nasals would contrast generally (IDENT(nasal) dominates *VOICEDSTOP and *NASAL). However, in codas voiced stops would neutralize with nasals (*μ/VOICESTOP dominates IDENT(nasal)).

Tableau (156) shows that this grammar produces total alterability of geminates.

(156) *Contextual markedness alone.*

/CVb^μV/	*μ/VOICESTOP	IDENT(nas)	*VOICEDSTOP	*NAS
a. [CVb^μV]	*!		*	
b. ☞ [CVm^μV]		*		*
c. ✘ [CVmbV]		*	*!	*

The fission candidate (c) is harmonically bounded by total alterability candidate (b). Candidate (c) violates IDENT(nasal), *VOICEDSTOP and *NASAL. Whereas candidate (b) violates only IDENT(nasal) and *NASAL. Since candidate (c) is harmonically bounded, this grammar predicts that fission will never occur. Also, candidate (a), the unaltered geminate candidate, violates *μ/VOICESTOP and is thus ruled out by this grammar.

Fission is also impossible with just positional faithfulness and general markedness. If we assume an analysis of coda neutralization, like that in Beckman (1997), where you have IDENT-ONSET(nasal) dominates *VOICEDSTOP which dominates IDENT(nasal), you predict that the outcome for geminates will be inalterability, not fission. Tableau (157) shows the result.

(157) *Contextual faithfulness alone*

/CVb^μV/	IDENTONS(nas)	*VOICEDSTOP	IDENT(nas)	*NAS
a. ☞ [CVb^μV]		*		
b. [CVm^μV]	*!		*	*
c. ✘ [CVmbV]		*	*!	*!

Again, the fission candidate (c) is harmonically bounded. This time the

[19] Removing onset faithfulness from the theory forces us to refuormulate the positional markedness constraint in more specific terms.

unaltered candidate, (a), violates a subset of the constraints violated by candidate (c). Candidate (c) violates *VoicedStop, Ident(nasal) and *Nasal. However, candidate (a) only violates *VoicedStop. Therefore fission can never be optimal in this grammar.

On the surface, cases of geminate fission appear to be a counterexample to the claim that markedness always prefers one segment to two and that geminates are single melodies. The analysis of fission in Alabama presented here shows that we can maintain single melody geminates inputs. However, it is important to look at how pair geminate inputs are dealt with in this grammar. Tableau (158) shows that pair geminates neutralize to fissioned geminates due to IdentOns(nas).

(158) *Pair geminate inputs*

/CVb_1b_2V/	IdentOns(nas)	*VC	*VoicedStop	Ident(nas)	*Nas
a. CV$m_{1,2}$V	*!			*	*
b. CV$b_{1,2}$V		*!	*		
c. ☞ CVm_1b_2V			*	*	*

Given a pair geminate input, the grammar prefers to keep the two segments separate and alter just the coda segment as in candidate (c). Candidate (b) where the pair geminate neutralizes to a singleton segment is ruled out because it violates the *V-VoicedStop markedness constraint. Fusing the pair geminate and altering it to a nasal (candidate (a)) is also ruled out since it violates the high ranked Ident-Onset(nasal).

In rankings like that proposed for Alabama here, two segments are preferred to one segment through the interaction of markedness and positional faithfulness. Although I argue in chapter two that pair geminates generally neutralize to singleton segments, in this case pair geminates neutralize with fissioned geminates. To ensure that pair geminates do not contrast with geminates in fission cases, there can be no Integrity constraint (McCarthy & Prince 1995), the correspondent to Uniformity. In addition, the moraic faithfulness constraint NoSpread must not be exhaustive.

The constraint Integrity is a general constraint against fissioning segments.

(159) *Anti-Fission Constraint*

Integrity "No Breaking"

No element of S_1 has multiple correspondents in S_2.

For $x \in S_1$ and $w, z \in S_2$, if $x\Re w$ and $x\Re z$, then $w=z$.

Since Integrity blocks fission in general it can distinguish the single melody geminate from the pair geminate input in the same way that Uniformity distinguishes between pair geminates and singletons. Tableau shows how Integrity can force violation of *V-VoicedStop or Ident-Onset(nasal)with geminate inputs, but not with pair geminate inputs.

(160) *Integrity distinguishes pair and single geminates*

/CVb_1b_2V/	Integrity	IdOns(nas)	*VC	*VoicedStop	Id(nas)	*Nas
a. CV$b_{1,2}$V			*!	*		
b. ☞ CVm_1b_2V				*	*	*
c. CV$m_{1,2}$V		*!			*	*
/CVb_1^{μ}V/						
d. ☞ CVb_1^{μ}V			*	*		
e. CVm_1b_1V	*!			*	*	*
f. ☞ CVm_1^{μ}V		*			*	*

Integrity is inactive on the pair geminate input. Therefore candidate (a) and (c) are ruled out by Ident-Onset(nasal) and *V-VoicedStop, as in the analysis above. However, Integrity is active on the single melody geminate input. If Integrity dominates Ident-Onset(nasal) or *V-VoicedStop, then candidate (d) or (f) will be optimal. Either way, pair geminates do not neutralize with single melody geminates. Therefore, Integrity cannot be a constraint in Con.

For similar reasons, the constraint NoSpread must be formulated as in

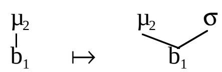
Chapter Two. In Chapter Two I argued that NOSPREAD can only care about the association from the mora to the segment. It cannot demand that the segment maintain its association to the mora. One reason, is that we do not want fission to violate the mora association faithfulness constraint.

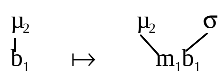
(161) *Reformulated NOSPREAD*

MAX-ASSOCIATION
If τ_1 is a mora in the input and it is associated to ζ_1 and $\tau_1\Re\tau_2$, and $\zeta_1\Re\zeta_2$ then τ_2 is associated to some ζ_2.

NOSPREAD is an input oriented constraint that quantifies over moras, not segments. The constraint checks to make sure that for every output mora associated to a segment which has an input correspondent that is a associated to a segment, the two segments are in correspondence. MAX-ASSOCIATION is satisfied in both mappings in (162).

(162) *Geminate Mappings*

a. 

b. 

The mapping in (a) satisfies MAX-ASSOCIATION since the output mora associated to b_1 has an input correspondent which is associated to the input correspondent of b_1. The mapping in (b) also satisfies MAX-ASSOCIATION since the mora associated to m_1 in the output has an input correspondent that is associated to b_1. The crucial aspect of the definition of MAX-ASSOCIATION is that it requires only some ouput correspondent of the segment to maintain the association to the mora. Every output correspondent does not need to maintain that association. Therefore, MAX-ASSOCIATION cannot block fission.

3.3.2 Faroese Verschärfung

If IDENT-ONSET(F) does not conflict directly with the specific markedness constraint that is driving the phonology, it will also be active. In this case, the candidate which preserves onset identity can simultaneously satisfy the demands of the phonological constraint. One example of this type of ranking is found in Faroese Verschärfung (Anderson 1972, Petersen, et al. 1998).

In Faroese some geminate glides are hardened to corresponding stop-fricative sequences. Hardening (Verschärfung) was a historical process. It is not clear whether it is part of the synchronic grammar of Faroese, although Anderson (1972) argues that it is. The examples in (163) are taken from Petersen, et al. (1998) with some minor changes in representation and show the effects of Verschärfung.

(163) *Hardening of* w

a. /ɹœw + a/ ↦ ɹœwwa ↦ ɹɛkva ‘row’

b. /ɹuw + a/ ↦ ɹuwwa ↦ ɹɪkva ‘pile’

Certain intervocalic glides are geminated in Faroese, and subsequently hardened. The crucial aspect of hardening for our purposes is that instead of hardening a glide to a geminate *k*, the glide hardens to a *kv* sequence.[20] Faroese thus contrasts with the Fula examples in section 3.2.3.1 where for example *ww* hardens to *bb*.

Recall that the ranking for Fula above involved an anti-paninian ranking between IDENT-ONSETAP and IDENTAP such that the general IDENTAP must dominate the specific IDENT-ONSAP. The Fula ranking is repeated here.

(164) *Fula ranking*

*GEMCONT » IDENTAP » *B,*F and *F » IDENT-ONSETAP

One possible re-ranking of the constraints in (164) has IDENT-ONSETAP above the general markedness constraints.

I propose that this re-ranking is exactly the ranking for Faroese.

(165) *Faroese ranking*

IDENTAP, IDENT-ONSETAP » *K,*V
&
*GEMCONT » IDENTAP

Having IDENT-ONSETAP ranked on a par with IDENTAP above featural markedness results in fission of the hardened geminate since the added markedness violation is traded off for improved Onset faithfulness. IDENT-ONSETAP and *GEMCONT do not conflict. Tableau (166) shows this result.

(166) *Geminate Fission*

/ɹɛw$^{\mu}$a/	IDENT-ONSETAP	*GEMCONT	IDENTAP	*K	*V
a. ☞ .ɹɛk.va.			*	*	*
b. .ɹɛk.ka.	*!		*	*	
c. .ɹɛw.wa.		*!			

The conflict is between the general markedness *V and the positional faithfulness IDENT-ONSETAP. IDENT-ONSETAP does not conflict with *GEMCONT since it is possible to satisfy both as in candidate (a). In fact candidate (a) is optimal in this language precisely because it satisfies both of these top ranked constraints.

3.3.3 Icelandic Preaspiration

In Icelandic an underlying geminate postaspirate is realized as a cluster of an *h* followed by an unaspirated stop as in (167). This process is referred to as preaspiration.

[20] Petersen et al note that "v is more like an approximant in many cases (ʋ)" (1998;24) .

(167) *Icelandic Preaspiration*

/pp^{h}/ ↦ hp

Preaspiration of geminates is part of a larger pattern of preaspiration where underlying postaspirated stops both geminate and singleton are affected. Below I will discuss the relevant environments where preaspiration occurs in Icelandic.

Viewed as geminate fission, preaspiration is problematic. The resulting cluster is unfaithful in both of the resulting segments. The aspiration segment is unfaithful to the stop portion of the segment and the stop segment is deaspirated. Since the stop segment is parsed as an onset, deaspiration violates IDENT-ONS(asp). Suppose preaspiration is driven by a constraint which dislikes post-aspirated segments. There are at least three possible repairs, either the stop portion deletes, the aspiration deletes or preaspiration occurs. The tableau (168) shows the faithfulness violations of these three options.

(168) *Preaspiration as fission*

/up_1^{h}i/	IDENT-ONS(cont)	IDENT-ONS(asp)	IDENT(cont)	IDENT(asp)
a. ✗ uh_1p_1i		*	*	*
b. up_1i		*		*
c. uh_1i	*		*	

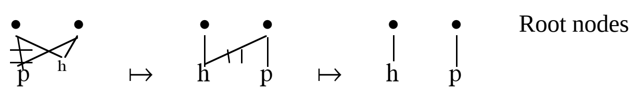
Fissioning the stop into two segments (candidate a) creates more faithfulness violations than deaspiration (candidate b). Since there are two imperfect segments on the surface each segment causes a faithfulness violation. In addition, from a markedness perspective candidate (a) will have a superset of the violations of the other candidates since it has the same segments plus one more as each of those. Therefore candidate (a) is harmonically bounded by candidate (b) and could not be optimal given these constraints.[21]

Instead of a fission account of preaspiration, I propose an analysis which treats aspiration as an autosegment. I propose that an autosegment in Correspondence theory is simply a segment. In this analysis, preaspiration is not a case of geminate fission since the stop and the aspirate are never one segment. Therefore Featural faithfulness is satisfied with preaspiration. Instead preaspiration is metathesis of two segments. This analysis has two advantages. First, it neatly captures the facts in Icelandic. Second, it shows that preaspiration is not a counterexample to the theory of geminate fission presented here.

There is good evidence that aspiration (and glottalization) is an autosegment. We find aspiration undergoing 'delink and spread' behavior. That is, some processes delink aspiration from its host stop and spread it to another part of the phonological string. Icelandic preaspiration is one example of delink and spread behavior. Grassmann's law in Sanskrit is another example.

Delink and spread behavior is exemplified in Icelandic preaspiration (Thrainsson 1978, Jónsson 1994). The example in (169) shows the autosegmental view of preaspiration.

(169) *Autosegmental view of Preaspiration* (Selkirk 1990)



First, the oral place specification of the stop is delinked from the first half of the geminate. Second, the aspiration is delinked from the second half of the stop. These two delinkings give the surface *hp* sequence.

In Grassmann's Law in Sanskrit (Borowsky & Mester 1983,

[21] Of course this does not mean that there could not be a constraint that distinguishes (a) from (b) and (c). However, I will assume that no such constraint exists.

Lombardi 1991) we also see evidence of the delink and spread behavior of aspiration. Examples of the distribution of aspiration in the Sanskrit root */budh/* 'to know' are given in (170)

(170) *Aspiration in the root* /budh/ *'to know'* Borowsky & Mester (1983)

a.	bodhati	3rd sg pres ind
b.	bubodha	3rd sg perf
c.	bhotsyati	3rd sg fut
d.	abhutsi	1rst sg aorist
e.	bhut	root noun, nom sg
f.	bhudbis	root noun, instr pl
g.	bhuddhvam	2nd pl pres imp

The examples in (76c - f) show that the aspiration on the final consonant may delink and spread to the initial consonant of the root.

The autosegmental behavior of aspiration suggests that aspiration is both part of a stop segment and independent of the stop segment (a segment unto itself). This fact requires us to rethink what it means for something to be a segment. In Optimality Theory, whether an object is a segment, or a sequence of segments follows from the constraints in UG: a group of features can be considered a segment if the constraints treat the grouping as a segment. The claim that a particular bundle of features is a segment depends on the particular formalization of constraints. However, we can make two general points. First, markedness constraints often care about the number and type of segments that can make up a complex syllabic position (e.g. *COMPLEXCODA and *COMPLEXONSET (Prince & Smolensky)). If the sequence *ph* passes markedness constraints like these, then for those purposes it is a segment. Second, the theory of faithfulness also defines a segment. Under the hypothesis in McCarthy & Prince (1995) that segments stand in correspondence, then x is a segment if it stands in correspondence with another segment. With respect to aspiration, it appears that the two definitions of segment are at odds. Constraints regulating the segment-prosodic structure interface treat *ph* as a single thing. However, constraints at the purely segmental level treat *ph* as two segments.

I propose that aspiration is a semi-independent segment. The representation of an aspirated stop is that in (171).

(171) *Aspirated Segments*

$$\begin{array}{cc} Rt_{i} & Rt_{i,j} \\ | & | \\ \text{Place} & \text{[asp]} \end{array}$$

Both root nodes in (171) share one index, since all prosodic constraints treat them as one segment. However, the aspirated portion of the segment also has its own root node and correspondent to indicate its autonomy.[22]

There are two problems with the bisegmental approach to aspiration. The first problem is that while aspiration and glottalization show autosegmental behavior, voicing does not. Voicing does not act independently of segment that hosts it. If all Laryngeal features may head separate segments, this asymmetry is surprising. The second problem is that neutralization processes treat the Laryngeals as a class (Lombardi 1991). For example, final Laryngeal neutralization often affects aspirated and voiced segments, neutralizing them to a voiceless segment.

As a solution to these problems I will adopt Padgett's (1995) Feature Class theory. In Feature Class theory, there is no Laryngeal node, rather the features *voice*, *aspiration* and *glottal* are marked as belonging to the class Laryngeal as in (172).

(172) *Laryngeal Feature Class* Padgett (1995)

Laryngeal: {voice, asp, glo}

In Feature Class theory, features are loosely collected under the root nodes.

[22] For purposes of this dissertation I assume that the representation in (77) is given in the input. However, no language contrasts the sequence *ph* with a monosegmental p^h. Ideally, this fact should be captured by

We can then state that aspiration and glottalization can head a segment, while voicing cannot, perhaps because these features are tied to the release of the segment (Ohala 1990, Kingston 1990) while voicing is not. However, Laryngeals can still behave as a class through the feature class. For example, if neutralization is the result of a ban on Laryngeal features in some position, for example finally (contra Lombardi 1991). The constraint responsible for Laryngeal neutralization can target the whole feature class, and thus affects both aspiration and voicing, despite the fact that they reside in different places segmentally.

Given the two-root representation of aspiration, we are now able to see the analysis of preaspiration as metathesis. Icelandic preaspiration is complicated by the interaction of syllable structure and syllable weight constraints with preaspiration. First I will demonstrate the core rankings needed to account for preaspiration in a simpler system. In this section I will look at the Mesoamerican language Tarascan which has freer preaspiration compared to Icelandic. Next I will describe the Icelandic facts and show how they are related to issues of syllable structure and stress. Then I will discuss the relationship between stress and weight in Icelandic. Finally, I show how preaspiration interacts with stress in Icelandic.

3.3.3.1 Tarascan

Tarascan has a simpler pattern of preaspiration than Icelandic. Tarascan contrasts unaspirated stops with aspirated stops. In Tarascan, aspirated stops are post-aspirated when a member of a word initial onset, preaspirated following vowels and deaspirated after consonants within the word (Foster 1969: 18-19).

the grammar. Therefore faithfulness should not be violated by merging *p* and *h* through coindexation.

(173) *Preaspiration in Tarascan*[23]

Member of a word-initial consonant cluster

a. p^{h}imani ‘to take it out of the water’

b. t^{h}irɛni ‘to eat’

c. t^{h}upuri ‘dust’

d. c^{h}awapiti ‘thin’

e. č^{h}apani ‘to fell a tree’

f. k^{h}eri ‘big’

g. šk^{h}ɛni ‘loose, lazy’

h. kt^{h}eeča ‘houses’

Post-vocalic

i. ɛhpu ‘head’

j. p^{h}ahtani ‘to touch the metate’

k. p^{h}ahcitni ‘to touch the table’

l. arahkuni ‘to cut oneself on the hand’

Post-consonantal word internally

m. /eratp^{h}erani/ → eratperani ‘to look each other in the eyes’

n. /xapt^{h}i/ → xapti ‘he had been there’

o. /karapc^{h}ini/ → karapcini ‘to have a swelling on one’s head’

p. /cakspk^{h}u/ → cakspku ‘many stones’

The examples in (173a-h) show that aspirated stops are post-aspirated initially. The examples in (173g and h) show post-aspiration initially when the stop is

[23] In these transcriptions I am ignoring other features of the language, such as final vowel devoicing.

the second member of an initial cluster. The examples in (173i-l) show the preaspiration of stops medially following vowels. Finally, examples (173m-p) show that aspirated stops are deaspirated following a medial consonant. There were no examples in Foster (1969) of an aspirated stop appearing pre-consonantally.

I propose that preaspiration is metathesis in response to a constraint against post-aspiration. Constraints on possible coda consonants and consonant clusters determine the availability of preaspiration to alleviate the markedness violation. The constraints I will assume for my analysis of preaspiration are given in (174).

(174) *Constraints*

*Stop-Asp (*Stop-H)	Do not have a stop followed by an aspirated segment.
No Preaspirate Onsets (*[hO)	Preaspirated sequences cannot be onsets.
NoCoda	Do not have codas.
Linearity	No metathesis.
Max	No deletion of segments.
Ident(F)	Do not change features.
Depµ	Do not insert a mora.

The constraint *Stop-Asp militates against post aspirated stops. The other constraints, *[hO, NoCoda, Linearity, Max, Ident(F) and Depµ conflict with *Stop-Asp since they are violated by potential repairs.

In (175) I show the mapping I assume for preaspiration.

(175) *Mapping for preaspiration*

/p$_{1}$h$_{1,2}$/ ↦ h$_{1,2}$p$_{1}$

*Linearity, √*Stop-H

The preaspiration mapping violates the faithfulness constraint Linearity since the semi-independent *h* follows the stop in the input but precedes it in the output. However, it satisfies the markedness constraint *STOP-ASP since the sequence *ph* is avoided. Ranking the constraints *STOP-ASP and MAX above LINEARITY makes this mapping optimal. The result is demonstrated in tableau (176).

(176) **STOP-ASP, MAX » LINEARITY - ranking needed for preaspiration*

$/p_1h_{1,2}/$	MAX	IDENT(F)	*STOP-ASP	LIN
a. ☞ $h_{1,2}p_1$				*
b. $p_1h_{1,2}$			*!	
c. p_1	*!			
d. $h_{1,2}$		*!		

Deletion of the aspirate segment (candidate c) is blocked by the high ranking MAX. MAX is violated here because the *h* corresponds to two segments. Candidate (d) which deletes the stop portion will not violate MAX since the aspiration is coindexed with the stop. However candidate (d) does violate IDENT(F). In addition, the faithful postaspirate candidate (b) is ruled out by the high ranking *STOP-ASP . Candidate (a) with preaspiration is optimal even though it violates LINEARITY. LINEARITY is forced to be violated by higher ranked MAX, IDENT(F) and *STOP-ASP.

There are two possible syllabifications for the consonant cluster *hp*, the outcome of preaspiration. First, the cluster may straddle a syllable boundary, so that *h* is in the coda of one syllable and *p* is in the onset of the following syllable. Second, both *h* and *p* may form a complex onset of a syllable.[24] Both syllabifications are marked choices since the first violates NOCODA[25], while the second violates *[hO. I propose that in Tarascan and Icelandic, only the first option is possible, while the second is avoided.

An important question is whether the sequence *hp* could ever be a complex onset. If there is no need for the constraint *[hO as a ranked and

[24] The third option, where both the *h* and the *p* form a complex coda is universally more marked than the other two and thus not available. Ommitting this possible outcome does not affect the argument here.
[25] As well as DEPμ if codas are moraic in the language.

violable constraint. However, free ranking of this constraint does predict that some languages would allow preaspirates as complex onsets. Steriade (1994) following Pike and Pike (1947) and Buckley (1990) shows that both Huautla Mazateco and Kashaya allow preaspirated stops (*h* + obstruent clusters) as onsets.

In Tarascan, preaspiration occurs only medially after vowels. Medially after consonants aspirated stops are deaspirated. If we set aside the word initial contexts, we can account for the distribution of aspiration in Tarascan with the following ranking.

(177) Tarascan preaspiration.

*[hO » *STOP-ASP » MAX » LIN, NOCODA, DEPμ

Since *STOP-ASP dominates LINEARITY, NOCODA and DEPμ, preaspiration will occur medially after a vowel. In this environment, preaspiration can straddle the syllable boundary. However, since *[hO and *STOP-ASP dominate MAX, after a consonant, deaspiration will occur. In this environment, preaspiration cannot straddle the syllable boundary since the preceding syllable contains a coda. Therefore preaspiration must form a complex onset. This option is blocked by *[hO and so deletion of the *h* is preferred.

Tableau (178) shows that preaspiration can create a coda *h* in Tarascan.

(178) *Preaspiration creates a coda h.*

/ephu/	*[hO	*STOP-H	MAX	LIN	NOCODA	DEPμ
a. .e.phu.		*!				
b. .e.pu.			*!			
c. ☞ .eh.pu.				*	*	*
d. .e.hpu.	*!			*		

Since *STOP-ASP dominates LINEARITY, NOCODA and DEPμ metathesis into the coda (candidate c) is optimal. Deletion (candidate b) is blocked by MAX dominating LINEARITY and NOCODA. Furthermore, *[hO must dominate at least NoCoda to prevent the preaspirate from forming a complex onset.

Tableau (179) shows that in Tarascan deaspiration is preferred to preaspiration post-consonantally.

(179) *preaspiration cannot be a complex onset.*

/xapthi/	*[hO	*Stop-H	Max	Lin	NoCoda	Depμ
a. .xap.thi.		*!			*	*
b. ☞ .xap.ti.			*		*	*
c. .xap.hti.	*!			*	*	*

Since *Stop-Asp dominates Max post-aspiration (candidate a) is worse than deaspiration (candidate b). Furthermore, with *[hO above Max, preaspiration (candidate c) is blocked.

Initially preaspiration and deaspiration are blocked. I attribute this fact to an active positional faithfulness constraint that dislikes deletion of segments in the intial syllable.

(180) *Initial faithfulness*

Max-Init — No deletion of segments in the initial syllable of the word.

With Max-Init ranked above *Stop-Asp, deaspiration is blocked in the initial syllable of a word. In addition, *[hO must dominate *Stop-Asp in order to prevent preaspiration initially.

(181) *Preaspiration and deaspiration blocked initially.*

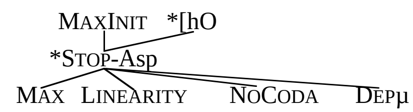
/thireni/	MaxInit	*[hO	*Stop-H	Max	Lin
a. ☞ .thi.re.ni.			*		
b. .ti.re.ni.	*!			*	
c. .hti.re.ni.		*!			*

Preaspiration (candidate c) can only form a complex onset and is blocked by *[hO. Deaspiration (candidate b) deletes a segment from the initial syllable. Therefore MaxInit must dominate *Stop-Asp. *Stop-Asp is inactive on

this candidate set.

The basic ranking for preaspiration is that *Stop-Asp must dominate Linearity, NoCoda and Depμ. With this ranking, preaspiration can metathesize as well as create a coda consonant. The diagram in (182) shows the other rankings that hold in Tarascan.

(182) *Tarascan rankings*



I will show that the same general ranking holds in Icelandic, with the exception of the position of MaxInit. However, other constraints on syllable weight conspire to block preaspiration in some environments in Icelandic where preaspiration would occur in Tarascan.

3.3.3.2 Icelandic

Icelandic has three kinds of surface stops: postaspirated, preaspirated and unaspirated. In the North dialect of Icelandic these stops have the following distribution.

(183) *Distribution of Icelandic stops* - North Dialect

		Aspirated	Preaspirated	Unaspirated[26]
Word initial	a.	.t^{h}aa.la. ‘talk’	*.htaa.la.	.taa.lʏr. ‘valley’
After long vowels	b.	.aa.p^{h}i. ‘monkey’	*.uu.hpi.	.ii.puð.[27] ‘habitation’
	c.	.sii.t^{h}ja. ‘sit’	*.sii.htja.	*.sii.tja.
	d.	.heiit^{h}. ‘hot’	*.haahp.	*.haat.
after short vowels	e.	*.k^{h}ɔ.p^{h}ɪ.	.uh.pi. ‘upstairs’	*.k^{h}ɔ.pɪ.
	f.	*.heit^{h}.	.hahp. ‘luck’	.snökk. ‘sudden’
	g.	*.ep^{h}.li.	.eh.pli. ‘apple’	.nak.lar. ‘nails’
after consonants	h.	.svun.t^{h}a. ‘apron’	*.svun.hta.	.han.ta. ‘for’
	i.	*.fɪs.k^{h}ʏr.	*.fɪs.hkʏr.	.fɪs.kʏr. ’fish’
	j.	*.sk^{h}ou:r.	*.shkou:r.	.skou:r. ’shoe’
Geminate	k.	*k^{h}ɔp^{h}:i	*k^{h}ɔhp:i	k^{h}ɔp:i ‘young seal’
	l.	*sat^{h}:ʏr	*saht:ʏr	sat:ʏr ‘sharpen
	m.	*sɪk:^{h}ʏ	*sɪhk:ʏ	sɪk:ʏ ‘Siggu’

The situation in Northern Icelandic is similar to that in Tarascan. Preaspirated and postaspirated stops are in complementary distribution. Preaspirated stops in Icelandic cannot occur initially, after consonants or after long vowels. Given the phonotactics of Icelandic, this means that preaspirated stops are not possible onsets. Like Tarascan, Icelandic has an undominated *[hO constraint. On the other hand, post aspirated stops cannot appear after short vowels. This distinction between post long vowels and post short vowels I

[26] Einarsson (1945) describes the unaspirated stops as slightly voiced intially.

argue is the due to the interaction between weight and stress in Icelandic. Unlike Tarascan, post aspirated stops do occur after some consonants. I argue that MAX is higher ranked in Icelandic than it is in Tarascan, accounting for the post-aspirated stops. In addition, there is some neutralization between aspirated and unaspirated stops. Neither pre nor post aspirated stops cannot appear after *s*. I assume that here preaspiration has occurred, but that merger has taken place between the aspiration and *s*. The result is a surface *s*-unaspirated stop cluster. I will not discuss this part of the analysis here, but see Keer (1998) for a full analysis. Furthermore, neither pre nor post aspirated stops can appear as geminates.

The geminate facts provide another piece of evidence that pre and post aspirated stops are allophones in Icelandic. Icelandic has a consonant length distinction. Unaspirated stops can be geminates. However, there are no postaspirate geminates.

(184) *Lack of aspirated geminates*

Unaspirated		Aspirated
k^{h}ɔppɪ	‘young seal’	*k^{h}ɔpp^{h}ɪ
sattʏr	‘sharpen’	*satt^{h}ʏr
sɪkkʏ	‘Siggu’	*sɪkk^{h}ʏ

Furthermore, the Icelandic orthography distinguishes between unaspirated stops (b, d, g) and postaspirated stops (p, t, k). Orthographic geminate aspirated stops are realized phonetically as singleton preaspirated stops.

[27] This word is bimorphemic, i-, buð. A brief survey of Einarsson’s (1945) glossary revealed no monomorphemic words with intervocalic unaspirated stops that were not geminates. The same holds for final stops. This issue deserves more research.

(185) *Orthographic geminate aspirates are phonetic preaspirates.*

Orthography	Phonetic	Gloss
uppi	uhpi	'upstairs'
happ	hahp	'luck'

Where we expect aspirated geminates from the orthography, we get preaspirated stops. The lack of aspirated geminates is accounted for if we assume that preaspirated stops are derived from underlying geminate aspirated stops. This analysis is also supported by morphological alternations like the one given in (186).

(186) *Morphological alternations* (See Thráinsson 1978 for more cases)

	Fem Sg.	Neut. Sg.	gloss
a.	sæl	sælt	'happy'
	aum	aumt	'miserable'
b.	fei:t^h	feiht	'fat'
	ljou:t^h	ljouht	'ugly'
	sai:t^h	saiht	'sweet'

The examples in (49a) show that the neuter singular marker for adjectives is /-t/. When this marker combines with a stem final $/t^h/$, the two merge and form a geminate, which is realized as a preaspirate. Thráinsson (1978) provides more cases that support the analysis here. The fact that geminates preaspirate in Icelandic follows from the proposed interaction of the preaspiration ranking and the constraints on syllable weight.

Northern Icelandic has preaspiration similar to Tarascan. Therefore the constraints *STOP-ASP and MAX must dominate LINEARITY, NOCODA and DEPμ. In addition we know that *[hO is active in the language since preaspiration does not form complex onsets. Instead preaspiration can only

form a heterosyllabic cluster. This is key to understanding why preaspiration is blocked following long vowels. I propose that preaspiration is blocked following long vowels due to constraints on vowel length in stressed syllables. In the next section I discuss the relationship between syllable weight and stress in Icelandic.

3.3.3.3 Stressed syllables

Icelandic, like other Scandinavian languages, requires stressed syllables to be heavy. Stress in Icelandic is on the initial syllable. All stressed syllables are either closed by a consonant (the first half of a geminate or consonant cluster) or contain a long vowel. I propose that this surface pattern is the result of the following mappings, where the first syllable is the stressed syllable.

(187) *Mappings in stressed syllables*:

a.	VVCV	↦	VV.CV	Underlying stressed long vowels are retained
b.	VCCV	↦	VC.CV	Underlying short vowels before clusters and geminates are retained
c.	VVCCV	↦	VC.CV	Underlying long vowels before clusters are shortened
d.	VCV	↦	VC.CV	Underlying short consonants are geminated after short vowels.

The most interesting mappings are those shown in (187c and d). In (187c) an underlying long vowel is shortened before a consonant cluster. Shortening only occurs when the consonant cluster cannot be parsed as a legitimate onset. In that case, vowel shortening and concomitant parsing of the the first consonant as a coda occurs. There is evidence from the morphology that this is the correct mapping (see example (192) below). In (187d) the underlying form does not have enough material to create the surface target of a heavy syllable. The traditional analysis of this case is that vowel lengthening occurs (Venneman 1972, Árnasson 1986). However, I argue that preaspiration provides evidence that gemination is the actual result.

In addition to the mappings given in (187) for stressed vowels, Icelandic also has only short vowels in unstressed syllables. Yet, geminates are allowed in both unstressed and stressed syllables.

I propose that the following constraints account for the distribution of heavy syllables in Icelandic.

(188) *Stress and weight constraints*

Stress-to-Weight	Stressed syllables must be heavy.
SonoritySequence	Complex onsets must rise in sonority.
Maxμ	Do not delete input moras. Every mora in S_1 has a correspondent in S_2.
Depμ	Do not insert a mora. Every mora in S_2 has a correspondent in S_1.
MaxAssociation	If τ_1 is a mora in the input and it is associated to ζ_1 and $\tau_1 \Re \tau_2$, and $\zeta_1 \Re \zeta_2$ then τ_2 is associated to some ζ_2.
NoLongVowel	Do not have a surface long vowel.
NoCoda	Do not have a coda consonant.

The general requirement that stressed syllables are heavy in Icelandic I attribute to the constraint Stress-to-Weight (Benua 1995). The SonoritySequence constraint is meant to capture the fact that complex onsets in Icelandic are restricted. The only complex onsets allowed are a stop (*p*,*t*,*k*) or *s* followed by a glide (*j*,*v*) or *r*. There are three faithfulness constraints on moras from Chapter one. The Maxμ constraint militates against deletion of input moras. The Depμ militates against the insertion of moras. The MaxAssociation constraint militates against deleting the association between a segment and a mora. NoLongVowel and NoCoda are both familiar markedness constraints against prosodic structure.

In Icelandic, there are no long vowels in unstressed syllables. I assume that long vowels shorten in unstressed syllables. Therefore, NoLongVowel

must dominate Maxμ.

(189) *Long vowels shorten*

/ɔfsiː/	NoLongVowel	Maxμ
a. .ɔf.siː.	*!	
b. ☞ .ɔf.si.		*

Given an input with a long vowel in an unstressed syllable, in this case the second syllable, Deletion of the mora is preferred to maintaining the long vowel.

Unlike long vowels, geminates are possible in unstressed syllables. Therefore, Maxμ must dominate NoCoda.

(190) *Geminates possible*

/cvcvccv/	Maxμ	NoCoda
a. .cv.cv.cv.	*!	
b. ☞ .cv.cvc.cv.		*

If an input has a geminate in an unstressed syllable, of the mora is preferred to shortening which would alleviate the NoCoda violation. Through transitivity of ranking we also know that NoLongVowel dominates NoCoda since Maxμ dominates NoCoda and is itself dominated by NoLongVowel.

We do find long vowels in stressed syllables. Therefore, long vowels do not shorten in stressed syllables. I propose that Stress-to-Weight and MaxAssociation dominate NoLongVowel.

(191) *Long vowels in stressed syllables.*

/ka:la/	StW	MaxAssn	NoLongVowel	Maxµ
a. ☞ .ka:.la.			*	
b. .ka.la.	*!			*
c. .kal.la.		*!		

With an underlying long vowel in a stressed syllable, deletion of the mora violates Stress-to-Weight and is fatal. The faithful long vowel can surface in this case. In addition, MaxAssociation must dominate NoLongVowel to prevent the second mora of the long vowel from spreading to the following consonant.

Long vowels in stressed syllables do shorten before consonant clusters and geminates. These inputs show the activity of the SonoritySequence constraint and the constraint against trimoraic syllables (*µµµ).I proposed above that underlying long vowels are shortened before consonant clusters as in (192).

(192) /naaklar/ ↦ [naklar]

This mapping is the result of SonoritySequence, which dislikes parsing [kl] as an onset, and *µµµ must dominate Maxµ, forcing shortening of the vowel.

(193) *Long vowels shorten before clusters.*

/naaklar/	SonSeq	*µµµ	StW	NoLong-Vowel	Maxµ	NoCoda	Max
a. .naa.lar.				*!		*	*
b. ☞ .nak.lar.					*	**	
c. .naak.lar.		*!				*	
d. .naa.klar.	*!					*	

In tableau (193), all candidates pass the Stress-to-Weight constraint. Candidate (d) violates SonoritySequencing since the consonant cluster is not a possible onset in the language. Candidate (c) violates the ban on trimoraic syllables, since coda consonants must be moraic in Icelandic. Therefore only candidates (a) and (b) are possible since they satisfy both of these top ranked constraints. Candidate (b) violates Maxµ since the long vowel is shortened. Since we know from above that NoLongVowel must dominate Maxµ, shortening of the vowel (candidate b) is preferred to deletion (candidate a). The relative ranking of Max cannot be decided by this input.

Long vowels also shorten before geminates. Again, we see the activity of *µµµ.

(194) *Long vowels shorten before geminates.*

/saattyr/	*µµµ	StW	NoLongVowel	Maxµ	NoCoda
a. .saa.tyr.			*!	*	*
b. ☞ .sat.tyr.				*	**
c. .saat.tyr.	*!				*

Candidate (c), which maintains both the long vowel and the geminate violates the *µµµ constraint. In this case, Maxµ must be violated. Therefore vowel shortening is preferred degemination since NoLongVowel dominates NoCoda.

To ensure that there are no light stressed syllables in Icelandic, I propose that light syllable inputs geminate the following consonant in order to meet the required heavy syllable template. The constraint Stress-to-Weight must dominate Depμ.

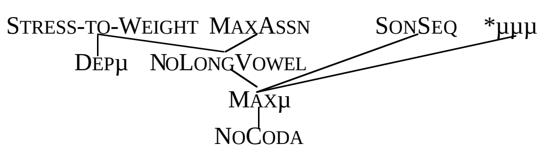
(195) *Light syllables geminate.*

/pana/	StW	Depμ	NoLongVowel	NoCoda
a. .paː.na.		*	*!	
b. ☞ .pan.na.		*		*
c. .pa.na.	*!			

Since Stress-to-Weight dominates Depμ, there are two possible candidates. Either the vowel is lengthened as in (a) or the consonant is geminated as in (b). As with overlong inputs, since NoLongVowel dominates NoCoda, gemination is preferred to vowel lengthening.

The facts of lengthening and shortening in stressed syllables in Icelandic motivate the following constraint rankings.

(196) *Icelandic Constraint rankings*



NoLongVowel dominates Maxμ causing long vowels in Icelandic to shorten in unstressed syllables. Since long vowels are preserved in stressed syllables, Stress-to-weight and MaxAssociation must dominate the constraint NoLongVowel. However, stressed long vowels are shortened before geminates and consonant clusters indicating that SonoritySequence and *μμμ must dominate Maxμ. Geminates, on the other hand, are possible in

unstressed syllables, therefore the constraint NoCoda, which disprefers geminates, must be dominated by the moraic faithfulness constraints Maxμ and MaxAssociation. Finally, since there are no light stressed syllables in Icelandic, the constraint Stress-to-Weight must dominate Depμ to force lengthening of underlying light syllables. This lengthening takes to form gemination since by the other established rankings NoLongVowel dominates NoCoda. Geminates are preferred to long vowels by this ranking.

3.3.3.3.1 Postaspirates

As above for Tarascan, I will assume that Icelandic preaspiration results from the ranking of *Stop-Asp over Linearity, NoCoda and Depμ. However, as in Tarascan the effect of this ranking may be blocked by higher ranking constraints, forcing post aspirates on the surface. In this section I will discuss the environments where post aspiration is found and the constraints responsible for it.

The surface distribution of postaspirates is word initially and following long vowels (see (183) above). These are the environments where the language demands that stop-aspirate sequence be parsed as an onset. The fact that preaspirates are blocked from this environment indicates that *[hO must dominate *Stop-Asp, restricting preaspiration from creating an illicit onset.

Word initially aspirated stops are postaspirated not preaspirated. Any preaspirate initially would necessarily be parsed as a complex onset due to the lack of a preceding syllable. This parsing violates the *[hO constraint. Ranking *[hO above *Stop-Asp blocks the preaspiration ranking as in (197).

(197) *Post-aspiration Initially* - *[hO » *Stop-H

/thaala/	*[hO	*Stop-H	Lin, NoCoda, Depμ
a. ☞ thaala		*	
b. htaala	*!		*

Preaspiration in candidate (b) violates *[hO since the *ht* sequence must necessarily be parsed as an onset. There is no preceding syllable that the *h* can form the coda of. Therefore the preaspiration mapping is blocked and we get a surface post-aspirate (candidate a).

After long vowels, aspirated stops are also postaspirated rather than preaspirated. Long vowels only occur in stressed syllables as stated above. This restriction is captured by the ranking in (198).

(198) *Long vowels in stressed syllables*

STRESS-TO-WEIGHT » NOLONGVOWEL » MAXμ

In order to maintain the heavy syllable requirement, long vowels are blocked from shortening. The fact that preaspiration does not occur following stressed long vowels indicates that it is better to preserve the long vowel than to avoid the marked stop-aspirate sequence. Therefore, MAXμ must dominate *STOP-ASP. The tableau in (58) shows this ranking argument between MAXμ and *STOP-ASP.

(199) *After Long Vowels* - *[hO, MAXμ » *STOP-ASP

/aaphi/	*[hO	*μμμ	MAXμ	*STOP-H	LIN, NOCODA, DEPμ
a. ☞ .aa.phi.				*	
b. .aa.hpi.	*!				*
c. .ah.pi.			*!		*
d. .aah.pi.		*!			*

Preaspirated stops cannot be a single onset as in candidate (b) due to the high ranking of *[hO. This is consistent with what we know from word initial aspirates. Furthermore, the preaspirated stops cannot straddle the syllable boundary in this environment because it would require shortening the long vowel. MAXμ blocks this shortening and so blocks the preaspiration mapping. Candidate (c) is ruled out because of the ban on trimoraic syllables which we know from above must dominate MAXμ.[28]

[28] The only overlong syllables in Icelandic ocur word-finally, therefore other constraints will be needed to

After voiced consonants aspirated stops are also postaspirated. We know from the previous two cases that *[hO would block preaspiration if it created a complex onset as in *.svun.hta*. Another possible repair is to simply delete the aspiration. This choice is blocked by a high ranking MAX constraint.

(200) *Deaspiration blocked by MAX.*

/svuun$_1$t$_2$h$_{2,3}$a/	*[hO	MAXμ	MAX	*STOP-H
a. .svun$_1$.h$_{2,3}$t$_2$a.	*!	*		*
b. ☞ .svun$_1$.t$_2$h$_{2,3}$a.		*		*
c. .svun$_1$.t$_2$a.		*	*!	

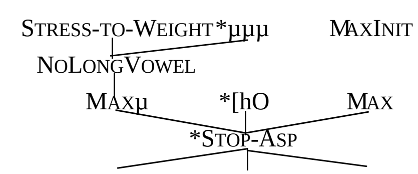
(201) *Deaspiration blocked by MAX*

/svun$_1$t$_2$h$_{2,3}$a/	*[hO	MAXμ	MAX	*STOP-H
a. .svun$_1$.h$_{2,3}$t$_2$a.	*!	*		*
b. ☞ .svun$_1$.t$_2$h$_{2,3}$a.				*
c. .svun$_1$.t$_2$a.			*!	

Candidate (c) in both tableaux is the deaspiration candidate. Deaspiration violates MAX since the aspiration is a semi-autonomous segment. Preaspiration, candidate (a) is blocked by the high ranking *[hO. Therefore postaspiration is the only choice.

The distribution of post aspirates motivates the following constraint rankings

(202) *Crucial rankings*



rule out non-moraic representations of these syllables word internally (c.f. the discussion of Persian above).

LIN NOCODA DEPμ

Two major differences between the ranking for Icelandic and that for Tarascan. First, the relative position of MAX (and MAXINIT). In Tarascan when preaspiration is blocked there is deaspiration, *STOP-ASP dominates MAX (except initially where MAXINIT is relevant). In Icelandic when preaspiration is blocked you get post aspiration, MAX dominates *STOP-ASP. Since deaspiration is blocked generally, the relative ranking of MAXINIT is indeterminate. Second, in Tarascan preaspiration is only blocked when it would create a complex onset. In Icelandic preaspiration is also blocked when it would shorten and underlying long vowel in a stressed syllable, MAXμ dominates *STOP-ASP.

In each case where post-aspirates surface as post-aspirates, we see that there is a constraint that blocks the preaspiration candidate from being optimal. In general this constraint is the markedness constraint *[hO. However, the faithfulness constraint MAXμ also blocks preaspiration. The interaction with MAXμ is crucial to understanding why geminates preaspirate.

3.3.3.3.2 Preaspiration

In Icelandic vowels are short in stressed syllables when the syllable is followed by a consonant cluster or a geminate. I proposed above that underlying long vowels are shortened before consonant clusters as in (203).

(203) /naaklar/ ↦ [naklar]

This mapping is the result of SONORITYSEQUENCE, which dislikes parsing [kl] as an onset. As I noted above, the SONORITYSEQUENCE constraint must dominate MAXμ, forcing shortening of the vowel. This ranking is restated in (204).

(204) SONSEQ » MAXμ

I will argue that vowel shortening enables the preaspiration candidate.

When an input contains the sequence stop - aspirate - sonorant the result is metathesis of the aspiration and the stop (preaspiration). Key to this

result is that parsing all three segments as a complex onset violates the SONORITYSEQUENCE constraint as does parsing only two segments in the onset and one in the coda of the preceding syllable. However, because the other candidates satisfy the STRESS-TO-WEIGHT constraint without violating NOLONGVOWEL, the most faithful candidate is not available. Preaspiration then is expected. The tableau (63) shows how preaspiration is enabled by SONORITYSEQUENCE.

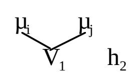
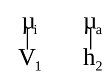
(205) *Preaspiration following long vowel enabled by SONSEQ.*

/eephli/	SONSEQ	NLV	MAXμ	*STOP-H	NOCODA	LIN	DEPμ
a. .ee.phli.	*	*!		*			
b. .ep.hli.	*		*	*!	*		*
c. ☞ .eh.pli.	*		*		*	*	*

Since NOLONGVOWEL rules out candidate (a), MAXμ must be violated.[29] Therefore the constraint is not active on the remaining candidates. The decision is passed onto *STOP-ASP which chooses in favor of preaspiration (candidate c). The blocking effects of MAXμ are ameliorated by the higher ranked NOLONGVOWEL.

The winning candidate in tableau (205) violates both MAXμ and DEPμ. MAXμ is violated since the mora of the input long vowel is deleted. DEPμ is violated because the *h* in coda position must get a mora by weight by position. Another possible candidate would be to allow flop between the long vowel mora and the coda *h*. The two candidate mappings are given in (206).

(206) *Moraic insertion/deletion vs. flop*

a.  a 

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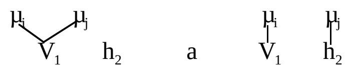
[29] I assume that MAX dominates SONSEQ, forcing all three segments to be syllabified.

b. 

The mapping in (a) violates MAXμ and DEPμ as I mentioned, but satisfies MAXASSOCIATION. By contrast, the mapping in (b) satisfies both MAXμ and DEPμ but violates MAXASSOCIATION. Both output candidates however have the same phonetic realization. The optimal candidate will be determined by the relative ranking of these three constraints. The stress facts above motivate MAXASSOCIATION dominating NOLONGVOWEL and by transitivity MAXμ in Icelandic (see example (196) above). Furthermore, the preaspiration facts motivate MAXμ dominating *STOP-ASP which in turn dominates DEPμ (see (202) above). Therefore, by transitivity of previous rankings, we know that MAXASSOCIATION dominates both MAXμ and DEPμ. Therefore the mapping in (a) is preferred to the mapping in (b) in Icelandic.

When the same sequence of segments as in (205) follows an underlying short vowel the result is also preaspiration, since again MAXμ is inactive. The tableau (207) shows this result.

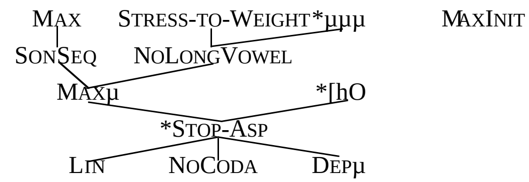
(207) *Preaspiration following short vowel follows from previous ranking.*

/ephli/	SONSEQ	NLV	MAXμ	*STOP-H	NOCODA	LIN	DEPμ
a. .ee.phli.	*	*!		*			
b. .ep.hli.	*			*!	*		*
c. ☞ .eh.pli.	*				*	*	*

MAXμ is rendered inactive by the lack of a long vowel in the input, thus enabling the preaspiration mapping as in (205).

The examples in this section motivate the following refinement of the rankings in (202) above.

(208) *Refined Icelandic rankings*



The ranking between SONORITYSEQUENCE and MAXμ was justified for Icelandic in the discussion of weight and stress above. In this section I have shown how this ranking also enables the constraint *STOP-ASP to block post aspiration.

Whenever MAXμ, which blocks preaspiration, is inactive due to crucial domination or lack of an input long vowel, preaspiration occurs. In the next section I will discuss how this claim also holds true for geminate inputs.

3.3.3.3.3 Geminates

The final environment where preaspiration occurs is with geminates. I argue that Maxμ which normally blocks preaspiration is inactive since the geminate provides the mora.

If we assume a geminate input following a long vowel, Maxμ is inactive and preaspiration occurs as in tableau (209).

(209) *An underlying geminate following a short vowel becomes preaspirated.*

$/upp_1h_{1,2}i/$	MAXμ	*STOP-H	DEPμ	NOCODA	LIN
a. ☞ $.uh_{1,2}.p_1i.$				*	*
c. $.up.p_1h_{1,2}i.$		*!		*	

Since MAXμ is inactive, the constraint *STOP-ASP can be active choosing candidate (b) with preaspiration over candidate (a) with post-aspiration. The faithfulness constraint MAXASSOCIATION is not violated by preaspiration, since the aspiration is associated with the mora through being coindexed with the stop. We see that with respect to prosodic constraints, the stop and the aspirate act like one segment.

If we assume a geminate post-aspirate following a long vowel, MAXμ is also irrelevant. In this case, the constraint must be violated due to the higher ranked ban on trimoraic syllables. The tableau in (210) shows how this occurs.

(210) *An underlying geminate following an underlying long vowel.*

/uupphi/	*μμμ	MAXμ	NLV	*STOP-H	NOCODA	DEPμ	LIN
a. ☞ .uh.pi.		*			*		*
b. .up.phi.		*		*!	*		
c. .uu.phi.		*	*!	*!			
d. .uup.phi.	*!		*				

Candidate (d) with the over-heavy syllable is ruled out as above. The remaining three candidates all violate Maxμ. Candidate (c) is ruled out by both NO-LONG-VOWEL and *STOP-ASP. Candidates (a) and (b) both violate NOCODA, but candidate (b) violates the higher ranked *STOP-ASP.

Derived geminates also lead to preaspiration. Since neither the vowel nor the consonant is long, MAXμ is irrelevant to this input. Therefore STOP-ASP is active as in tableau (211).

(211) *An underlying singleton following an underlying short vowel preaspirates.*

/uphi/	MAXμ	*STOP-H	NOCODA	DEPμ	LIN
a. ☞ .uh.pi.			*	*	*
b. .up.phi.		*!	*		
c. .uu.phi.		*!		*	
d. .u.phi.		*![30]			

With MAXμ irrelevant, candidate (b) through (c) are ruled out by *STOP-ASP. All that is required is that *STOP-ASP dominate DEPμ, NOCODA and

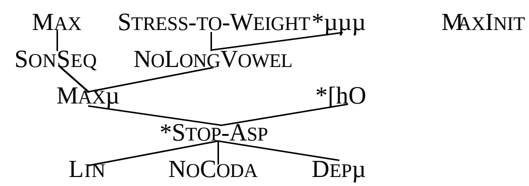
[30] This candidate also violates the requirement that stressed syllables be heavy and so is ruled out by STRESS-TO-WEIGHT as well.

LINEARITY.

3.3.3.4 Conclusion

The particularly complex set of Icelandic facts with respect to preaspiration results from the following ranking of the proposed constraints.

(212) *Icelandic rankings*



The core ranking is that between *STOP-ASP and LINEARITY, NOCODA and DEPμ. This ranking prefers preaspiration to alleviate a *STOP-ASP violation. Furthermore ranking MAX above *STOP-ASP prevents deletion of aspirates when preaspiration cannot occur. The two constraints that directly dominate *STOP-ASP block preaspiration in certain environments. With *[hO above *STOP-ASP, preaspiration is blocked from creating a complex onset. Finally with MAXμ above *STOP-ASP, preaspiration cannot shorten a long vowel in a stressed syllable. However, we know that MAXμ is itself dominated by other constraints. It is exactly when these constraints force violation of MAXμ or the input circumvents the Maxμ violation, that *STOP-ASP again becomes relevant and forces preaspiration.

Comparing the Icelandic ranking in (212) with the ranking for Tarascan in (182), the crucial difference is the placement of MAXμ. In Icelandic, Maxμ (and the all the constraints which dominate it) dominates *Stop-Asp. Therefore preaspiration is blocked in a range of contexts where it would shorten a long vowel. However in Tarascan MAXμ does not dominate *STOP-ASP, therefore preaspiration in Tarascan can occur in a wider range of contexts than Icelandic.

The analysis presented here maintains a single melody analysis of geminates. LINEARITY is violated under compulsion of *STOP-ASP. Metathesis can only take place when syllable structure allows it. That is, when a consonant cluster forces insertion of a mora. By comparison, a two-root theory of preaspiration must lengthen coda consonants, for example in /ɛp^{h}li/, to feed preaspiration, then shorten coda consonants which do not preaspirate (see Hermans 1985). The effect of lengthening in consonant clusters is opaque. It only serves to trigger preaspiration.

Icelandic preaspiration occurs with both single segments and geminates. By assuming the bisegmental representation of aspirated segments we can capture the complex facts in Icelandic as well as the simpler Tarascan facts. Given the assumptions made here, preaspiration with geminates follows from preaspiration with non-geminates. Geminates are special in that they come pre-associated to a mora. Since Maxμ is the constraint that blocks preaspiration, geminates necessarily undergo preaspiration. Also, since aspiration is semi-autonomous, preaspiration does not violate IDENT(F). Therefore preaspiration is not a counter example to fission being driven by IDENT-ONS(F).

3.3.4 Features as segments

Lombardi (1998) gives an analysis of fission in Japanese that treats the features voice and nasality on a par with segments, so that they have MAX and DEP constraints ranging over them. In addition, They assume privative nasal and voice features. In this section I will briefly explain Lombardi's analysis and compare it with the analysis of fission presented here.

Japanese has a case of geminate fission that is parallel to Alabama. Voiced stops nasalize in coda position and voiced geminates are also banned. Morphological gemination of voiced consonants fission them to nasal, voiced consonant clusters. The examples in (213) show the results of morphological gemination in Japanese.

(213) *Morphological gemination in Japanese* (Lombardi 1998)

a. *Voiceless Consonants*

Base	*Intensified*	*Gloss*
bata	battari	'with a bang'
huku	hukkuri	'plump. puffy'
yap	yappari	'nevertheless'

b. *Voiced Consonants*

Base	*Intensified*	*Gloss*
zabu	zamburi	'with a splash'
koga	koŋgari	'brown'

Geminate voiced stops fission into nasal plus voiced stop clusters.

Lombardi proposes that voiced geminates are marked by a constraint specifically targeting voiced geminates. It is the interaction of these constraints with faithfulness constraints that results in geminate fission.

(214) *Constraints* (Lombardi 1998)

NOVOICEDGEM	Do not have voiced geminates in the output
MAXVOICE	A Voice autosegment in the input must be present in the output
DEPNAS	Do not add the feature [nasal]
FAITHONSSON	Do not change Sonorant in the onset

Lombardi argues that the fission of geminates in Japanese is driven by the markedness constraint NOVOICEDGEM which militates against voiced geminates. Compare this constraint with the *VC constraint used above. In addition she assumes three faithfulness constraints. MAXVOICE and DEPNAS militate against deleting voice and inserting nasality respectively. See the discussion of MAX-IO and DEP-IO FEATURE in Chapter two. Finally Lombardi also assumes a positional faithfulness constraint FAITHONSSON, which penalizes any change in the feature sonorant when the hosting segment is parsed as an onset. These four constraints interact to produce the fission of geminates in Japanese.

In order for fission to occur, NOVOICEDGEM and MAXVOICE must dominate DEPNAS. The ranking argument is given in tableau (215).

(215) *Fission forced by MAXVOICE and NOVOICEDGEM*

/nobi + ri/			NOVOICEDGEM	MAXVOI	DEPNAS
a.		nobbiri	*!		
b.	☞	nombiri			*
c.	☞	nobmiri			*
d.		noppiri		*!	

Since NOVOICEDGEM is ranked above DEPNAS, the faithful candidate (a) is dispreferred relative to the fission candidates (b) and (c). Also, since MAXVOI dominates DepNas, the devoicing candidate (d) is dispreferred relative to candidates (b) and (c). Given this ranking, fission is the optimal outcome. However, the direction of fission remains unaccounted for.

In addition to the two general faithfulness constraints, Lombardi also assumes a positional faithfulness constraint on the feature sonorant. The tableau in (216) shows that with this constraint in the grammar, fission with the faithful segment in the onset is preferred universally to fission with the faithful segment in the coda.

(216) *Directionality of Fission due to Positional Faith*

/nobi + ri/			FAITHONSSON	DEPNAS
a.		nobmiri	*!	*
b.	☞	nombiri		*
c.		nommiri	*!	*

All three candidates are unfaithful with respect to DEPNAS to the same degree. They each violate the constraint once. However, the unattested fission pattern (candidate a) and the total alterability candidate each violate FAITHONSSON while candidate (b) does not. These constraints universally

prefer *mb* to *bm* and *mb* to *mm* from the input geminate *b*.

Lombardi's analysis of geminate fission, although it relies on MAX/DEP-IO FEATURE is basically the same as that given above in section 3.3.1. Since Positional faithfulness is the force that drives fission, the predictions are the same. However as I stated above in Chapter two, the MAX/DEP-IO view of features is incompatible with the view of the lexical OCP that I propose.

3.3.5 Conclusion

In this section, I have argued that geminate fission is driven by Onset faithfulness. This analysis accounts for the asymmetry observed in (141). Furthermore, it predicts that fission is only possible with left edge constraints. Finally, this analysis of fission does not require pair geminates as the representation of geminates. Rather, pair geminates will neutralize with single melody geminates in fission cases.

3.4 Conclusion

In this chapter I have shown that geminate alterability results in two possible outcomes for the geminate; total alterability and fission. Total alterability occurs when the constraint driving the phonological change is a right edge constraint and IDENT-ONSET(F) is inactive. Fission occurs when the constraint driving the phonological change is a left edge constraint and IDENT-ONSET(F) is active.

4. Geminate Inalterability

4.1 Introduction

Geminate inalterability effects have been discussed in some detail in the literature (see for example, Guerssel 1978; Hayes 1986; Schein and Steriade 1986; etc.). These effects are divided into the three cases given in (217).

(217)*Geminate Inalterability* (Guerssel 1978; Schein and Steriade 1986)

a. Geminates are not split by epenthesis

$*C_i^{\mu} \quad \mapsto \quad C_iVC_i$

b. Geminates are not split by phonological changes

$*C_i^{\mu} \quad \mapsto \quad C_jC_i$

c. Rules are blocked from applying to geminates

$*C_i^{\mu} \quad \mapsto \quad C_j^{\mu}$

First, geminates are not split by epenthetic processes as in (217a). That is, an underlying geminate does not surface as two identical consonants surrounding an epenthetic vowel. I briefly discussed Palestinian Arabic in Chapter two, which shows this behavior of geminates. Second, geminates also are not split by phonological changes as in (217b). An underlying geminate does not surface as a sequence of two similar consonants, where one consonant has undergone a phonological change. I have shown counterexamples to this claim in Chapter three and discussed constraint rankings required to derive effects of this type. Finally, some rules are blocked from applying to geminates although they appear in the triggering environment of the rule. Tiberian Hebrew Spirantization is an example of this type of behavior in geminates.

I propose that inalterability occurs when the markedness constraint responsible for the change fails to mark the faithful geminate output.

Blocking effects with geminates fall into two categories depending on how the markedness constraint fails to mark the geminate. In some cases geminates do not violate the markedness constraint or violate it to a lesser degree than other candidates. In these cases geminates are universally exempt from the process. Since the unaltered candidate is universally less marked than the altered candidate, no grammar will choose the altered candidate. I will discuss cases of universal inalterability in section two of this chapter. The most discussed case of universal inalterability is spirantization (Churma 1988). I will examine Tiberian Hebrew as a representative case of spirantization which is universally blocked by geminates. With other processes blocking arises through constraint domination. In this case, geminate inalterability is not universal, but reranking of constraints will result in geminate alterability. I will discuss such parochial inalterability in section three.

In addition I will discuss the failure of geminates to be affected by coda place restrictions. Geminate inalterability with respect to coda restrictions is another universal inalterability case. Another case of universal inalterability is seen with coda restrictions. Geminates universally pass such coda restrictions (Itô 1986). I propose, following Beckman (1997) that faithful geminate candidates fail the markedness constraint responsible for coda restrictions, but do so to a lesser degree than altered candidates. Therefore geminates are universally inalterable with respect to coda conditions.

4.2 Universal Inalterability

Universal inalterability occurs when candidates which are faithful to the geminate do better than, or at least as well as, other candidates on the markedness constraint responsible for the change. I propose that in the case of spirantization, geminates pass the markedness constraint driving spirantization. Since geminates pass the constraint they are under no pressure to spirantize.

In section 4.2.1 I will discuss Tiberian Hebrew as a representative case of spirantization not affecting geminates. I will introduce the constraint responsible for spirantization in this section. In addition I will discuss the typological consequences of the constraint. I will also briefly discuss four other languages with spirantization that does not affect geminates. These languages motivate proposing a family of markedness constraints banning continuants at different places of articulation as well as voicing.

4.2.1 Spirantization - Tiberian Hebrew

This section will focus on the resistance of geminates to spirantization. Of the cases cited in the literature blocking of spirantization with geminates appears to be universal (Guerssel 1978; Hayes 1986, 1990; Schein and Steriade 1986). I have found six languages; Tiberian Hebrew (Sampson 1973, Leben 1980), Tigrinya (Schein 1981), Tümpisa Shoshone (Dayley 1989), Ibibio (Connell 1991), Tamil (Christdas 1988) and Wolof (Ka 1994), all of which have spirantization processes that fail to affect geminates. I have found no languages where spirantization affects geminates. I assume that geminate non-spirantization is universal (Churma 1988). To account for the lack of geminate spirantization I propose that the markedness constraint responsible for spirantization does not mark geminates.

In section 4.2.1.1 I discuss the notion of release with respect to consonants. Consonantal release will be crucial to the formulation of the constraint driving spirantization. In section 4.2.1.2 I discuss the analysis of Tiberian Hebrew spirantization. In section 4.2.1.3 I discuss the typological predictions of this analysis. Finally in section 4.2.1.4, I discuss other languages with spirantization.

4.2.1.1 Release

A key feature of this analysis is that it relies on the idea that the release of consonants is represented in the phonology. I borrow from Steriade (1993a, 1994) the hypothesis that root nodes are classified into four types given in (218).

(218) *Release types*

a. A_0 Complete closure.
b. A_f Fricative closure.
c. A_{Appr} Approximant closure.
d. A_{Vowel} Vocalic root node.

I assume that the A_{Appr} and A_{Vowel} nodes form a natural class A_{Open} to which constraints can refer. Furthermore, I follow Steriade in assuming that stops, but not fricatives or approximants, are bipositional. They are composed of a sequence of A_0 and A_{Appr} nodes.

Steriade notes that this representation creates a potential segmental contrast. However, no language contrasts released stops with unreleased stops. In an Optimality Theoretic grammar a contrast results when Faithfulness dominates markedness, as discussed above in Chapter two. If a constraint demanding faithfulness to release dominated a markedness constraint that prefers released or unreleased stops, both underlying released stops and underlying unreleased stops would surface faithfully. The language would then contrast released and unreleased stops.

Suppose there is a markedness constraint that disprefers unreleased stops (for example see the constraint RELEASE in (225) below). If it is dominated by DEP as in (219) then the language will contrast released and unreleased stops.

(219) *Potential stop contrast from DEP » RELEASE*

a. /A_0A_{Appr}/	DEP	RELEASE
i. ☞ A_0A_{Appr}		
ii. A_0		*!

b. /A_0/	DEP	RELEASE
i. A_0A_{Appr}	*!	
ii. ☞ A_0		*

The contrast occurs since DEP rules out candidate (219b i). However, since no language makes this contrast, this result must be blocked. I assume that projection of the A_{Appr} in (219b i) does not violate DEP since the projected A_{Appr} position can be in correspondence with the underlying A_0 position as in (220) (superscript numerals represent the correspondence relation).

(220) *Projecting the release as fission*

$$A_0^{1} \mapsto A_0^{1}A_{Appr}^{1}$$

Since the A_{Appr} position has a correspondent in the input, DEP is satisfied. Furthermore, since the A_{Appr} position is featurally empty, no IDENT violations are incurred. Under this assumption no surface contrast will emerge as shown in (221).

(221) *No stop contrast through fission*

$/A_0^1/$	DEP	RELEASE
i. ☞ $A_0^1 A_{Appr}^1$		
ii. $A_0^1 A_{Appr}^2$	*!	
iii. A_0^1		*!

Candidate (221 i), with fission, wins since it satisfies both the markedness constraint and the faithfulness constraint. Candidates (221 ii and iii) are out because they each violate one of the two constraints.

A contrast could also arise through the interaction of a markedness constraint that disliked released stops[31], *RELEASE, with the faithfulness constraint MAX. If Faithfulness dominated the markedness constraint, underlying released stops would surface as released and underlying unreleased stops would surface as unreleased.

[31] For example the constraint NOSHORTCLOSURE below dislikes released stops preconsonantally.

(222) *Potential stop contrast from MAX » *RELEASE*

a. $/A_0A_{Appr}/$	MAX	*RELEASE
i. ☞ A_0A_{Appr}		*
ii. A_0	*!	

b. $/A_0/$	MAX	*RELEASE
i. A_0A_{Appr}		*!
ii. ☞ A_0		

The troublesome candidate is (222a ii); deletion of an underlying A_{Appr} could be worse than violating a markedness constraint on the distribution of released stops, leading to a contrast. I propose that an alternative candidate wins. The fusion mapping in (223) is the winner in (222a).

(223) *Deletion of release through fusion*

$$A_0^{1}A_{Appr}^{2} \mapsto A_0^{1,2}$$

Fusion of the two positions allows MAX to be satisfied since all input segments have an output correspondence. Again, since the A_{Appr} position is featurally empty, no IDENT violations are incurred.

(224) *No stop contrast through fusion*

a. $/A_0^1 A_{Appr}^2/$	MAX	*RELEASE
i. $A_0^1 A_{Appr}^2$		*!
ii. ☞ $A_0^{1,2}$		
iii. A_0^1	*!	

Candidate (224 ii), with fusion, wins since it satisfies both the markedness constraint and the faithfulness constraint. Candidates (224 i and iii) are out because they each violate one of the two constraints. Through allowing free fusion and fission, we see that an underlying potential contrast can be universally neutralized. In both cases, the presence of the stop is mandatory and licenses the presence or absence of release.

I propose that there is a markedness constraint on release with stops that account for its distribution.

(225) *Release constraint*

RELEASE Stops are released. Align(A_0, R, A_{Open}, L)

The constraint RELEASE follows the spirit of Steriade's release Projection rule (1994: 208). It requires that all stops be followed by either an A_{appr} or an A_V. Since faithfulness is not active in deciding the output for released stops the relative ranking of RELEASE with respect to markedness constraints that disprefer released stops will determine the distribution of released stops. If RELEASE dominates those markedness constraints, then the language will have released stops in all positions. If the ranking is reversed so that the markedness constraints against released stops are dominant, then the language will have released stops in restricted positions. In the analysis of spirantization I present here I explore the interaction of RELEASE with one such constraint.

4.2.1.2 Tiberian Hebrew: Sampson (1973), Leben (1980)

In Tiberian Hebrew the stops /p, t, k, b, d, ɡ/ are to a first approximation[32] in complementary distribution with the fricatives /f, θ, x, β, ð, ɤ/. The stops are found in initial and post-consonantal position, while the fricatives are found post-vocalically.

(226) *Tiberian Hebrew post-vocalic spirantization* Sampson (1973)

a.	kâθaβ	'he wrote'	mixtâβ	'letter'
b.	malkâ	'queen'	melex	'king'

Grammarians have long recognized a process of spirantization that changes underlying stops into continuants post-vocalically. Leben (1980) presents a simplified version of Sampson's (1973) rule which I provide here.

[32] In this analysis I am ignoring the opaque cases of surface spirants clusters due to vowel deletion. See Wilson (1996) and McCarthy (1998) for analyses.

(227) *Spirantization* (simplified)(Leben 1980)

[-son] → [+cont] / V____

If we unpack this rule into the relevant constraints it appears that there is a markedness constraint which dislikes non-continuants post-vocalically. In Tiberian Hebrew this constraint is active in that it dominates the relevant Faithfulness constraint allowing the mapping from non-continuant to continuant in this environment.

The data in (228) shows that geminates in Tiberian Hebrew fail to undergo spirantization despite the fact that they occur post-vocalically.

(228) *Failure of Spirantization with geminates* Sampson (1973)

a. ɡâðal 'he became great'

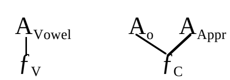
b. ɡiddel 'he raised (educated)'

c. *ɡiððel, *ɡiðdel, *ɡiðel (from underlying /ɡiddel/)

While it is true that for singletons spirantization occurs post-vocalically, for geminates this is not the case. I take the fact that geminates fail to spirantize to be evidence that the simple environment for spirantization given in the rule in (227) is not adequate.

If we assume that all surface stops must be released in Tiberian Hebrew (RELEASE is active), then the environment for spirantization can be more precisely rendered as in (229) where f_V indicates vowel features and f_C indicates consonant features.

(229) *The representation of post-vocalic released consonant*



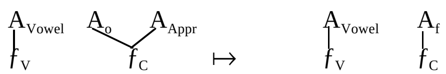
The representation in (229) shows the environment where non-continuants are disliked. This environment is more detailed than that in (227) since it includes the post consonantal environment. Given this, I propose that the driving force behind spirantization is a constraint that militates against having a short consonantal closure between two open positions as in (230).

(230) *Spirantization constraint*

NO SHORT CLOSURE (NOSHORTCLOS) Do not have an A_o linked to one syllable position (σ or μ) between two A_{Open} positions, where A_{Open} positions are either A_{Appr} or A_{Vowel}.

NOSHORTCLOSURE only dislikes short stops. Post-vocalic geminates pass the constraint and thus are under no pressure to spirantize. In (231) I show the mapping that NOSHORTCLOSURE forces. In Spirantization environments, a released stop becomes a fricative.

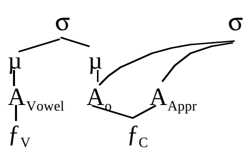
(231) *Mapping in spirantization environments*



NOSHORTCLOS is satisfied in this mapping since the resultant A_f is not subject to the constraint. Simply merging the A_0 and the A_{Appr} will violate the constraint RELEASE, which I argue is high ranked in spirantization.

I assume the following representation for post-vocalic geminates.

(232) *Post-vocalic Geminates*



Released geminates are made up of two parts, a stop closure and a release, just like singleton released stops. However, the crucial difference is that the stop portion of the geminate is long, that is associated to two syllable timing units. Therefore, the A_0 node in (232), although it is between two Open positions, passes the NOSHORTCLOSURE constraint by virtue of its length.

In (233) I present the other constraints that are relevant for this analysis.

(233) *Other relevant constraints*

*CONT	Do not have an output segment with the features [-son, +dist, A_f][33]
*STOP	Do not have an output segment with the feature [-son, A_0]
IDENTAP	Input and output segments match for Aperture specification
DEPμ	Do not insert a mora.

The constraints *CONT and *STOP are both featural markedness constraints that militate against combinations of specific features within a single segment. The constraint IDENTAP is a faithfulness constraint of the type proposed in McCarthy and Prince (1995) which regulates the mapping from input to output. DEPμ was discussed earlier in Chapter two. Example (234) shows how these constraints need to be ranked to account for Tiberian Hebrew.

(234) *Proposed ranking for Tiberian Hebrew*

NOSHORTCLOS, RELEASE, DEPμ » *CONT » *STOP, IDENTAP

With *CONT dominating *STOP and IDENTAP, the default consonant will be a non-continuant. However, with the markedness constraint NOSHORTCLOS and the Faithfulness constraint DEPμ ranked above *CONT, in the relevant environment continuants will surface.

4.2.1.2.1 Spirantization

Spirantization occurs when NOSHORTCLOS and RELEASE dominate *CONT and IDENTAP as in (235). This ranking forces the generally marked continuant to surface post-vocalically even at the cost of having a marked segment and changing an underlying aperture specification.

[33] The use of [+dist] blocks the constraint from applying to coronal fricatives [s, ṣ, ś, š] which appear in the language.

(235) *Spirantization ranking*

NoShortClos, Release » *Cont, IdentAp

The tableau in (236) shows the spirantization of a post-vocalic stop.

(236) *Post vocalic spirantization*[34]

/miktab/	NoShortClos	Release	*Cont	*Stop	IdentAp
a. mik|taβ	*!			*	
b. miktaβ		*!		*	
c. ☞ mixtaβ			*		*

Given an underlying post-vocalic stop, as in (236) the ranking chooses spirantization candidate (c) as the optimal output. Having a released stop post-vocalically (a) avoids the *Cont violation but at the expense of the high ranked NoShortClos. Whereas having an unreleased stop (b) avoids the NoShortClos violation, it incurs a Release violation which is also fatal. Since both NoShortClos and Release dominate *Cont the featural change is optimal.

This ranking also predicts spirantization in onsets. There, it is phonetically impossible to have an unreleased stop since the following vowel is necessarily an open position. Since it is an Open position, the consonant satsifies Release. Therefore candidate (b) from tableau (236) cannot be considered and (a) would be out by NoShortClos as above.

[34] In the tableaux I only provide the violations for the particular consonant under scrutiny. All other changes/violations are ignored for purposes of exposition. Furthermore, release is indicated with a'|' and single root geminates are indicated with a superscript μ, 'C$^{\mu}$'.

(237) *Spirantization in onsets*

/kâtab/	NoShortClos	Release	*Cont	*Stop	IdentAp
a. kât|aβ	*!			*	
b. ☞ kâθaβ			*		*

Since (a) is ruled out by the high ranked NoShortClos, candidate (c) is optimal. It violates the lower ranked *Cont but crucially not NoShortClos or Release.

Spirantization in Tiberian Hebrew emerges as the result of constraint conflict. Spirants in general are more marked than stops. However, stops are more marked than spirants when surrounded by open positions. NoShortClos and Release are ranked above *Cont in Tiberian Hebrew.

4.2.1.2.2 Stop as the default/ blocking environments

The above ranking accounts for spirantization. In the non-spirantization environment stops are the default consonant. This indicates that whenever NoShortClosure is irrelevant, we will find surface stops. Therefore *Cont must dominate both *Stop and IdentAp.

(238) *Stops are the default*

*Cont » *Stop, IdentAp

Under the ranking in (238), posited underlying stops will surface as stops and posited underlying continuants will also surface as stops. The Tableaux (239) and (240) show the ranking arguments.

(239) *Default Stop*

/mixtâb/	NOSHORTCLOS	RELEASE	*CONT	*STOP	IDENTAP
a. ☞ mixt|âβ				*	
b. mixθâβ			*!		*

Since NOSHORTCLOS is satisfied by both candidates in (239), the decision is made by the relevant ranking of the lower four constraints. Candidate (b) violates both *CONT and IDENTAP. Ranking either of these constraints above *STOP results in (a) being the optimal candidate. The tableaux in (240) shows that *CONT must dominate *STOP.

(240) *Default Stop with Spirant Input*

/mixθâb/	NOSHORTCLOS	RELEASE	*CONT	*STOP	IDENTAP
a. ☞ mixt|âβ				*	*
b. mixθâβ			*!		

If we posit a fricative in the input it must also surface as a stop. This indicates that IDENTAP cannot be the constraint responsible for blocking spirantization in tableau (239), since as (240) shows in this situation the constraint violation profile is reversed for this constraint. The hardened candidate (a) now violates IDENTAP in addition to *STOP. Only ranking *CONT above *STOP can force hardening in this case.[35] Note that the stop in candidate (a) does not violate NOSHORTCLOS since the preceding fricative does not have a release, it is simply an A_f.

Geminates are another case where the default stop surfaces since NOSHORTCLOS is not relevant. Tableau (241) shows that there is no pressure for an underlying geminate stop to spirantize.[36]

[35] Note that universal markedness considerations also support this ranking.

[36] Since geminates are always intervocalic in Tiberian Hebrew I will not consider unreleased candidates. See the discussion of spirantization in onsets above.

(241) *Geminate Stop*

/gid$^{\mu}$el/	NOSHORTCLOS	RELEASE	*CONT	*STOP	IDENTAP
a. ☞ gid$^{\mu}$|el				*	
b. gið$^{\mu}$el			*!		*
c. gið d|el			*!	*	*

The faithful parse in candidate (a) is optimal since it only violates *STOP. We know from tableau (240) that this violation is not fatal. Candidate (b) fails for the same reason that spirantization of non post-vocalic stops fails; the spirant is more marked than the stop. Candidate (c) shows a fissioned geminate where the first half of the geminate has undergone spirantization and the second half has not. This candidate is harmonically bounded by (a) under this set of constraints and so can never be optimal.[37] The analysis predicts geminate inalterability affects of the type in (217b). Because NOSHORTCLOS is satisfied by geminates we also derive geminate inalterability effects in (217c).

The results in tableau (241) hold even if we posit an underlying geminate spirant as in (242). The ranking *CONT » *STOP, IDENTAP ensures that this spirant will surface as a stop.

(242) *Geminate Spirant as input*

/gið$^{\mu}$el/	NOSHORTCLOS	RELEASE	*CONT	*STOP	IDENTAP
a. ☞ gid$^{\mu}$|el				*	*
b. gið$^{\mu}$el			*!		
c. giðd|el			*!	*	*

[37] Candidate (c) is harmonically bounded by candidate (a) even if we assume the positional Faithfulness constraint IDENT-ONSAP. As I have shown in Chapter three, general markedness constraints of the type *SEGMENTX cannot produce fission of geminates.

Candidate (b) is out because of the higher ranked *CONT, as with the short spirant input in tableau (240). Candidate (c) is now harmonically bound by (a). Thus switching to a spirant input does not destroy the results from (241).

The analysis of spirantization presented here rests on two assumptions. First of all, I assume that all stops are released, even in codas. This results from the activity of RELEASE in Tiberian Hebrew. Secondly, I assume that geminates are single melodies. This follows from the proposal in Chapter two about the nature of the Faithfulness constraints.

To see how the proposal works, consider positing pair geminates as inputs. There are four possible combinations of input stops, considering that each stop can be either released or not in the input. Each of these four inputs maps to the same output, a single fricative in the spirantizing environment.

(243) *Mappings for fake geminates*

a. $A_0^{1}A_{Appr}^{2}A_0^{3}A_{Appr}^{4} \mapsto A_f^{1,2,3,4}$
d d ð

b. $A_0^{1}\quad A_0^{2}A_{Appr}^{3} \mapsto A_f^{1,2,3}$
d d ð

c. $A_0^{1}A_{Appr}^{2}A_0^{3} \mapsto A_f^{1,2,3}$
d d ð

d. $A_0^{1}\quad A_0^{2} \mapsto A_f^{1,2}$
d d ð

Since neither the merger of closure and release, nor the merger of identical adjacent segments violates faithfulness, Markedness constraints decide the output. The least marked result in this environment is a single spirant segment.

The tableaux in (244) shows the results ignoring the release or lack of release in the input since it is not contrastive.

(244) *Identical adjacent stops as input*

/giddel/	NOSHORTCLOS	RELEASE	*CONT	*STOP	IDENTAP
a. giððel			**!		**
b. gid|d|el	**!			**	
c. ☞ giðel			*		*
d. gid|el	*!			*	
e. giðd|el			*	*!	*

We see that an immediate result is that splitting cannot occur. Candidate (e) is harmonically bounded by (c) and so can never be optimal. Candidate (b) is harmonically bounded by candidate (d) and candidate (a) is harmonically bounded by candidate (c). This indicates that coalescence is universally preferred over non-coalescence despite any featural changes that may occur. Candidates (c) and (d) really compete. Candidate (d) is out by high ranking of NOSHORTCLOS.

These results do not change if we consider adjacent spirants in the input rather than stops. Here we need only consider one input since spirants do not have a release related to them.

(245) *Identical adjacent spirants*

/giððel/	NOSHORTCLOS	RELEASE	*CONT	*STOP	IDENTAP
a. giððel			**!		
b. gid|d|el	*!			**	**
c. ☞ giðel			*		
d. gid|el	*!			*	*
e. giðd|el			*	*!	*

Again, candidate (e) is harmonically bounded by (c), splitting cannot occur. Candidate (b) is also harmonically bounded by (d) and candidate (a) is harmonically bounded by (c). Only (c) and (d) compete. Candidate (d) loses for the same reason as above.

The results also hold if we assume that one of the input pair geminate segments is moraic. The only difference is that the resulting fused segment is a geminate and therefore a stop rather than a continuant. For example consider the input /gid$^{\mu}$del/ where the first member of the pair geminate is moraic.

(246) *Identical adjacent stops as input*

/gid$^{\mu}$del/	NoShortClos	Release	*Cont	*Stop	IdentAp	MaxAssn
a. gið$^{\mu}$ðel			**!		**	
b. gid|$^{\mu}$d|el	**!			**		
c. gið$^{\mu}$el			*!		*	
d. ☞ gid|$^{\mu}$el				*		
e. gið$^{\mu}$d|el			*!	*!	*	

The constraint MaxAssociation is satisfied by all the candidates, therefore its ranking cannot force the input pair geminate to stay a pair geminate. See the discussion of MaxAssociation in the preceding chapters.

Suppose we try to mirror the effects of geminate splitting by positing an underlying form which contains the desired output form. We see that the analysis presented here with one further ranking of constraints, neutralizes this input to a single consonant. The tableau in (247) shows the results of the current constraint ranking with respect to this input.

(247) *Nearly identical adjacent segments*

/giðdel/	NoShortClos	Release	*Cont	*Stop	IdentAp
a. giððel			**!		*
b. gid|d|el	*!			**	*
c. ☞ giðel			*		*
d. gid|el	*!			*	*
e. ☞ giðd|el			*	*	
f. gidd|el		*!		**	

Candidates (b) and (e) are again harmonically bounded. However, (f) is now no longer harmonically bounded by (d) since the two no longer share a faithfulness violation. The competition between them hinges on the ranking between *Stop and IdentAp. Since we did not have evidence for the ranking between *Stop and IdentAp previously, the ranking predicts either (d) or (f) to be the winner, depending on the ranking we choose. Ranking *Stop above IdentAp gives (d) as the winning candidate as shown in (248).

(248) *Nearly identical adjacent segments*

/giðdel/	NoShortClos	IdentWt	*Cont	*Stop	IdentAp
d. ☞ giðel			*		*
e. giðd|el			*	*!	

This ranking predicts that Tiberian Hebrew cannot have consonant clusters where the two consonants agree in place but differ in continuancy. These clusters will automatically fuse in this language. This prediction is correct.[38]

[38] If we admit a syllable contact constraint that dislikes candidate (e) dominating Ident(Ap), then the ranking of *Stop and Ident(Ap) can remain indeterminate.

The situation with respect to pair geminates is different if we add a UNIFORMITY constraint which dislikes coalescence. The tableau in (249) shows two relevant candidates from a pair geminate input.

(249) *Addition of UNIFORMITY, an anti-fusion constraint.*

/giddel/	NOSHORTCLOS	RELEASE	*CONT	*STOP	IDENTAP	UNIFORM
d. giðel			*		*	*
e. giðd|el			*	*	*	

Candidate (e) is no longer harmonically bounded by (d). Here, the relative ranking of *STOP and UNIFORMITY determines the outcome. Therefore, a language could contrast pair and single melody geminates. Since no language does this I propose that UNIFORMITY is not a constraint of Universal grammar as in Chapter two above.

4.2.2 Why constraint conflict won't work

One question that arises is why we don't treat geminate inalterability as simply a case of constraint conflict. Using the resources of OT, we could posit a blocking schema to explain geminate inalterability effects as in (250).

(250) *Blocking Schema*

$\mathbb{C}_S$ » $\mathbb{C}_M$ » $\mathbb{C}_F$, $\mathbb{C}_{M'}$

A Markedness constraint ($\mathbb{C}_M$) dominates a relevant Faithfulness constraint ($\mathbb{C}_F$) and Markedness constraint ($\mathbb{C}_{M'}$). This sets up a mapping from underlying marked input string /m/ to less marked surface m´. However, under special circumstances, a constraint ($\mathbb{C}_S$) which dislikes m´ blocks this mapping. See *the emergence of the unmarked* McCarthy and Prince (1995).[39] This seems quite reasonable and in fact is exactly how I get

[39] In the emergence of the unmarked, the special case ($\mathbb{C}_S$) is actually input-output faithfulness, and the mapping to less marked only occurs in violation of the less restrictive base-reduplicant faithfulness.

spirantization in section 2.1.2.1 above. For geminate inalterability we could posit a ranking like that in (251).

(251) *Possible blocking schema for Tiberian Hebrew spirantization*

Geminate Inalterability » *$VC_{[-cont]}$ » IDENTAP, *CONT

This alternative is attractive since it allows us to state the markedness constraint responsible for spirantization in its simplest form, i.e. as a sequencing constraint *$VC_{[-cont]}$. Although positing a constraint 'geminate inalterability' is ad hoc, we do not need to look far to find a reasonable constraint to replace it with. Geminate spirants are known to be marked and sometimes subject to hardening (i.e. Paradis 1988, 1992 for Fula, Anderson 1972 for Faroese, and Dayley 1989 for Tümpisa Shoshone) as I discuss in Chapter three. In fact, I propose a markedness constraint against geminate continuants in that chapter.

(252) *Geminate Markedness Constraint*

*GEMCONT No Geminate continuants. Bakovic (1995)

Replacing 'geminate inalterability' in (251) with *GEMCONT, we get the following constraint ranking.

(253) *Geminate blocking*

*GEMCONT » *$VC_{[-cont]}$ - Spirantization blocked from creating a marked geminate

The ranking in (253) correctly predicts that geminates will fail to undergo spirantization. However, free reranking of constraints predicts that geminate resistance to spirantization is non-universal. The ranking given in (254) allows spirantization to create the marked geminate continuant.

(254) *Geminate alterability*

*$VC_{[-cont]}$ » *GEMCONT - Spirantization produces a marked geminate

The only way to prevent the result in (254) is to propose that the ranking in (253) is a universal ranking. This is clearly an unsatisfactory solution. There is no connection between the two constraints that could motivate such a universal ranking. Since the typological predictions of an OT analysis rest on free reranking of constraints, a blocking analysis of geminate inalterablity fails to capture the universal aspect of this phenomenon. I will show below in section three that some geminate inalterability cases are amenable to a blocking analysis of this type.

4.2.2.1 Typology

In the analysis presented here, no reranking of the above constraints can produce a grammar which has spirantization that affects geminates. This is simply because geminates pass the constraint which forces spirantization. There is no blocking of spirantization with respect to geminates. This is clear in tableau (242), repeated here.

(255) *Geminate Stops*

/gid$^{\mu}$el/	NOSHORTCLOS	RELEASE	*CONT	*STOP	IDENTAP
a. ☞ gid$^{\mu}$|el				*	
b. gið$^{\mu}$el			*!		*
c. giðd|el			*!	*	*

The tableau clearly shows that the ranking of NOSHORTCLOS is irrelevant for this candidate set.

However, this analysis does predict some typological variation. I will restrict the discussion to languages which do not have a contrast between stops and spirants, and where the default consonants are stops. That is where the lower portion of the ranking in (234), *CONT »*STOP » IDENTAP, is held constant. For these languages, the constraint violation profile for intervocalic stops is given in (256).

(256) *Constraint violation profile for intervocalic stops*

/ata/	NOSHORTCLOS	RELEASE	*CONT	*STOP	IDENTAP
a. aθa			*		*
b. at|a	*			*	

One important aspect to note is that no candidate violates release. As I mentioned above, intervocalic stops must be released into the following vowel. So although there are three possible output candidates[40], only two can be considered since an unreleased stop cannot occur. This is not the case when we consider stops in codas as shown in (257).

(257) *Constraint violation profile for coda stops*

/atka/	NOSHORTCLOS	RELEASE	*CONT	*STOP	IDENTAP
a. atk|a		*		*	
b. aθk|a			*		*
c. at|k|a	*			*	

Here all three candidates are possible outcomes. Therefore depending on the constraint ranking, languages can differ on how they treat intervocalic stops as opposed to stops in clusters.

Free reranking of these three constraints (NOSHORTCLOS, RELEASE, and *CONT) produces four languages.

[40] I am not considering other possible constraint interactions, such as deletion, etc.

(258) *Predicted languages*

Ranking	Coda Stops	Intervocalic Stops	Language
a. NoShortClos, Release, » *Cont	Spirantization	Spirantization	Tiberian Hebrew; Sampson (1978), Leben (1980)
b. *Cont, Release, » NoShortClos	Released Stops	Released Stops	Bella Coola; Bagemihl (1991)
c. NoShortClos » *Cont » Release	Unreleased Stops	Spirantization	Catalan; Wheeler (1979), Mascaro (1984)
d. *Cont » NoShortClos » Release	Unreleased Stops	Released Stops	English

Two languages (258 a,b) are characterized by having either NoShortClos or *Cont lowest ranked. The lowest ranked of these constraints determines the outcome for stops regardless of their position. However, if Release is lowest ranked stops will be unreleased when they are in the coda. The second lowest ranked of the remaining two constraints determines what happens to intervocalic stops since the unreleased candidate is unavailable. Again we have two possibilities (258 c,d) depending on which of NoShortClos or *Cont is the second lowest ranked constraint.

Tiberian Hebrew has *Cont as the lowest ranked member of this subhierarchy. Therefore, as we have seen, both intervocalic and coda stops are spirantized. If NoShortClos is the lowest ranked constraint then the language will not have spirantization and will have released stops in all environments. Since Release and *Cont are ranked above NoShortClos, released stops are optimal. If the language allows stops in coda then this

ranking predicts that they will also be released there. Bella Coola, Bagemihl (1991), may be a representative case of this ranking.

When release is the lowest ranked constraint coda consonants will be unreleased, however the relative ranking of the remaining two constraints will determine what happens to intervocalic stops. With *Cont as the lowest ranked of the remaining constraints, the language will have unreleased stops in codas and spirants intervocalically. Catalan (Wheeler 1979, Mascaro 1984) may be representative of this ranking. If NoShortClos is the second lowest ranked the language will have unreleased stops in codas and released stops intervocalically. English fits this profile.

4.2.2.1.1 Fortition in spirantization environments?

Geminate inalterability effects are captured in this analysis since geminate stops pass the constraint. Since geminates pass the spirantization constraint a language could map underlying singleton stops onto geminate stops in the environment where spirantization occurs in Tiberian Hebrew (post-vocalically) or only intervocalically (as spirantization in Catalan). Suppose that lengthening is reigned in by the faithfulness constraint Depμ (McCarthy 1997, Urbanczyk 1995).[41] The relative ranking of Depμ with respect to the three constraints above, determines where a language will lengthen stops. There are two possible languages. If Depμ is the lowest ranked of the constraints then the language will lengthen all post-vocalic stops. If Depμ is ranked above Release but below *Cont and NoShortClosure then the language will lengthen only inter-vocalic stops. These languages are not attested.

The fact that lengthening languages do not exist is problematic for this analysis. However, I believe that this is reducible to a general problem in OT, indeterminacy of repair (i.e. Wilson's 1997, pathological rankings). Free interaction of constraints predicts a larger range of repair strategies than is actually attested. For example the sequence of a nasal segment followed by

[41] ƒ(x) is the correspondence relation.

an oral vowel is universally marked. Many languages repair this sequence by nasalizing the vowel. However many other repairs are conceivable, which are not utilized. No language for example deletes vowels after nasals or nasal segments before vowels.

There are two possible approaches to the indeterminacy of repair problem. The first is that we simply have not uncovered the correct constraints and that the interaction of the right constraints will produce all and only possible human languages. The second approach is to limit the way in which constraints may interact. Since the problem is pervasive in Optimality Theory I lean toward the latter solution. However, a proper treatment of this problem is beyond the scope of this dissertation.

4.2.2.2 Other cases

In this section I will explore the other cases of spirantization mentioned above in section 1.1. These languages have the same general constraint ranking as Tiberian Hebrew with a few interesting differences. The main point of this section is that the single markedness constraint *CONT in the analysis of Tiberian Hebrew is actually a family of constraints representing the markedness of different feature combinations. Some of these constraints are given in (259).

(259) *Family of markedness constraints*

*LABIALCONT	Do not have a labial continuant.
*ALVEOLARCONT	Do not have an alveolar continuant.
*VELARCONT	Do not have a velar continuant.
*VOICEDCONT	Do not have a voiced continuant.
*VOICELESSCONT	Do not have a voiceless continuant.

These markedness constraints capture the fact that continuants at different places of articulation and different voicing specifications can be separated with respect to markedness. Languages treat these segments as marked to different degrees. In Tiberian Hebrew all continuants are equally marked.

That is, spirantization can create any of them. However, spirantization is restricted from creating some of these segments in these other languages as we will see.

These languages all share the property that they have underlying stops, but not underlying spirants. That is they share the ranking *CONT » *STOP » IDENTAP. Furthermore, all have spirantization of stops to some degree. Therefore in all the languages below, NOSHORTCLOS and RELEASE dominate some members of the *CONT family. The differences arise in to what extent the various markedness constraints in (42) dominate NOSHORTCLOS. Depending on which if any of these constraints dominate NOSHORTCLOS, spirantization will be restricted in some way.

4.2.2.2.1 Tigrinya

Tigrinya has a series of seven stops as in (260).

(260) *Tigrinya Stops*

	labial	alveolar	velar	uvular
voiceles s	p	t	k	q
voiced	b	d	g	

Stops are spirantized post-vocalically. However, spirantization in Tigrinya only affects the stops *k* and *q*.

(261) *Tigrinya spirantization* Kenstowicz (1982), Schein (1981).

a.	mɨbtʌx	‘to cut’
b.	bʌtʌxa	‘we cut’
c.	sʌnduχay	‘my box’
d.	bʌrʌxa	‘he blessed’
e.	mʌχdɨdati	‘instrument for well digging’

f. mʌχʌmmʌcʌ 'buttocks'

g. sʌrʌhka *or* sʌrʌhxa 'work-PERF-2sg'

h. nay bɨ-ray kisad *or* nay bɨ-ray x̲ɨsad 'the ox's neck'

Also, as in Tiberian Hebrew, spirantization does not affect geminates.

(262) *Lack of spirantization with geminates*

a. fʌkkʌrʌ, *fʌxxʌrʌ 'boasts'

b. yɨbtʌkko, *yɨbtʌxxo 'let him sever it'

The pattern is exactly the same as that of Tiberian Hebrew. There is post-vocalic spirantization of stops which fails to affect geminates. Again, the only difference is that spirantization is restricted to the voiceless back stops.

I propose that the restrictions on Tigrinya spirantization stem from markedness considerations on the output of spirantization. In Tigrinya spirantization can create a velar continuant but not a labial or alveolar. Furthermore, spirantization can only create a voiceless continuant, but not a voiced one. These restrictions show the activity of *LabialCont, *AlveolarCont, and *VoicedCont as in (263).

(263) *Tigrinya ranking*

*LabialCont, *AlveolarCont, *VoicedCont » NoShortClos » *VelarCont, *VoicelessCont, IdAp

NoShortClos is restricted in Tigrinya to only being active on voiceless velar stops.

With the three markedness constraints above NoShortClos in Tigrinya, stops that are spirantized in Tiberian Hebrew remain stops in Tigrinya. These stops remain stops despite the fact that IdAp is subordinate to NoShortClos. Tableaux (264) through (266) show the blocking of spirantization with respect to these stops.

(264) **LabialCont » NoShortClos*

/apa/	*LabialCont	NoShortClos	IdAp
a. aɵa	*!		*
b. ☞ apa		*	

(265) **AlveolarCont » NoShortClos*

/kafata/	*AlveolarCont	NoShortClos	IdAp
a. kafaθa	*!		*
b. ☞ kafata		*	

(266) **VoicedCont » NoShortClos*

/ʔaʔdugay/	*VoicedCont	NoShortClos	IdAp
a. ʔaʔduɣay	*!		*
b. ☞ ʔaʔdugay		*	

NoShortClos is forced to be violated with these stops due to the higher ranked markedness constraints.

With voiceless velar stops the situation is different. Now the markedness constraints against velar continuants and voiceless continuants are subordinated to NoShortClos. Therefore spirantization occurs.

(267) *NoShortClos » *VelarCont, *VoicelessCont, IdAp*

/bʌrʌka/	NoShortClos	*VelarCont	*VoicelessCont	IdAp
a. bʌrʌka	*!			
b. ☞ bʌrʌxa		*	*	*

Since the markedness constraints are subordinate to NOSHORTCLOS as is IDAP, spirantization occurs with voiceless velar consonants.

4.2.2.2.2 Tamil

According to Christdas (1988) Tamil has a series of six stops.

(268) *Tamil stops*

labial	dental	alveolar	retroflex	palatal	velar
p	t̪	t	ʈ	c	k

These stops are lenited intervocalically except when stem initial as the second member of a compound. In addition intervocalic voicing affects the labials and alveolars. The palatals and velars are not voiced intervocalically.

(269) *Spirantization of Tamil stops*

p	↦	ʋ
t̪	↦	ð
t	↦	r
ʈ	↦	ɖ
c	↦	s
k	↦	x

All stops spirantize in Tamil except the retroflex stop. This is understood as the retroflex rhotic being a marked segment. The retroflex rhotic does have a limited distribution in Tamil and Christdas notes that "Several speakers tend to replace /ɻ/ by the retroflex /ɭ/ in non-derived words" (1988;160).

Tamil does not allow consonant clusters, other than homorganic nasals and a few limited rising sonority clusters. Therefore we do not know if lenition affects first members of consonant clusters. Tamil does have geminates, and lenition does not affect them.

The analysis of spirantization in Tamil will be the same as that in Tiberian Hebrew, with the exception that retroflex stops do not spirantize.

(270) *Tamil ranking*

*ɻ » NOSHORTCLOS » *CONT, IDAP

With *ɻ ranked above NOSHORTCLOS, spirantization will be blocked with retroflex stops. However, since NOSHORTCLOS dominates the other markedness constraints against continuants (*CONT) and IDAP, spirantization occurs with the other stops.

4.2.2.2.3 Tümpisa Shoshone

Spirantization in Tümpisa Shoshone follows the now familiar pattern. Stops are spirantized intervocalically with the exception of geminates. There are two twists to the story here. First, nasals are affected by the spirantization, as well as oral stops. Second, the alveolar stop assimilates in place to the preceding vowel. It is an alveolar flap after nonfront vowels and an interdental fricative after front vowels. I will ignore the variation with the alveolar stop here.

(271) *Tümpisa Shoshone spirantization*

p, k, k^w	↦	β, ɣ, $ɣ^w$	after vowels
t	↦	ɾ	after nonfront vowels
t	↦	ð	after front vowels
m	↦	w̃	after vowels
n	↦	ỹ	after front vowels

Note that two changes take place. The stop is spirantized as well as voiced. I will treat the voicing as part of a larger pattern of voicing assimilation (as in Tamil above) to be discussed later. Note that voicing occurs only between two voiced segments. Before voiceless vowels and after [h], these segments are voiceless.

As in all the cases presented here, geminates fail to undergo spirantization despite the fact that they occur in the spirantization environment.

(272) *Geminates fail to spirantize*

tɨasɨppɨ̥	‘frozen’	sakka	‘that (obj)’
ɨppɨihḁ	‘sleeping’	sikkɨ̥	‘right here’
uttun̥n̥ḁ	‘to give’	pakk^{w}asi	‘Olanche, CA’
kuttin̥n̥ḁ	‘shoot’	ukk^{w}ḁ	‘when, if’
mɨatstsɨwiðɨ	‘four’	kimman̥n̥ḁ	‘to come’
tɨkkan̥n̥ḁ	‘to eat’	nɨmmɨ	‘we (exc)’’

This pattern shows that the spirantization is the result of NoShortClos and Release being active in the language, as in Tiberian Hebrew above.

(273) *Spirantization ranking for stops*

NoShortClos, Release » *Cont, IdAp - Spirantization of stops

The fact that spirantization in Tümpisa Shoshone affects nasals as well as stops indicates that the markedness constraint *NasalCont is subordinated to NoShortClos.

(274) *Spirantization ranking for nasals*

NoShortClos » *NasalCont

With this ranking, spirantization can create the marked nasal continuant. In the other languages discussed in this chapter, *NasalCont dominate NoShortClosure.

Unlike oral stops, nasals do not spirantize when they are the first members of a consonant cluster. This fact supports the view presented here

that spirantization is related to the release of stops. Nasals are unreleased when they are pre-consonantal, and therefore should not spirantize in this environment. Note that nasals place assimilate in this environment as shown in (275).

(275) *Nasal place assimilation*

taziumbi	‘star’
puŋgu	‘pet, horse’
ondɨmbitɨn	‘(yellowish) brown’

Place assimilated nasals must be unreleased. Since they are unreleased, they are not in the environment for NoShortClosure and therefore do not spirantize.

4.2.2.2.4 Wolof

Wolof (Ka 1994) has a series of six stops, five of which have voiced-voiceless pairs.

(276) *Wolof Stops*

labials	alveolars	palatals	velars	uvulars
p	t	c	k	q
b	d	j	g	

The voiceless series, except *t*, spirantize intervocalically and finally as does the voiced stop *d*. The velar *k* is actually deleted entirely. Otherwise the voiced stops do not spirantize.

(277) *Wolof stop mappings*

p ↦ f

d ↦ r

c ↦ s

k ↦ Ø

q ↦ x

Again, geminate voiceless stops are not spirantized. Also, word internal codas do not appear to occur.

The following rankings hold in Wolof.

(278) *Wolof rankings*

*VOICEDCONT » NOSHORTCLOS » IDAP, *VOICELESSCONT - voiced stops do not spirantize while voiceless stops do.

*VELARCONT » MAX » *VOICELESSCONT, *LABIALCONT, *ALVEOLARCONT - underlying voiceless velar stops delete but other voiceless stops spirantize.

IDENTVOICE, *θ » NOSHORTCLOS - underlying voiceless alveolar stops do not spirantize or become *r*.

We can account for the odd behavior of the segment *d* if we assume that it spirantizes to *r* because *r* does not violate *VOICEDCONT.

4.2.2.3 Conclusion

This section has shown that the same basic constraint ranking that holds in Tiberian Hebrew also holds in Tamil, Wolof, Tigrinya and Tümpisa Shoshone. The differences between the languages follow from reranking of the now divided *CONTINUANT markedness constraint.

4.2.3 Intervocalic voicing

Tamil and Tümpisa Shoshone have voicing of consonants which has properties similar to spirantization. Voicing occurs between two voiced segments, and does not affect geminates. However, voicing is clearly separate from spirantization. It occurs in a different environment, i.e. post-nasally as

well as post-vocalically. Voicing occurs when spirantization does not as in Tamil. Also, spirantization occurs when voicing does not as in Tiberian Hebrew. The voicing constraint must be similar to the spirantization constraint. I propose that the constraint responsible for voicing is NOSHORTVOICE as in (279).

(279) *Voicing constraint*

NOSHORTVOICE Do not have a voiceless segment linked to one timing slot between two voiced segments.

One can imagine that there is a family of constraints that dislike rapid changes in articulators. Kirchner (1998) proposes the constraint LAZY which has very similar effects. The constraints NOSHORTCLOSURE and NOSHORTVOICE are two members of this family. Whether other constraints exist is an empirical matter.

Voicing in Tamil affects both the labials and alveolars but not velars. Importantly voicing does not affect geminates. I propose the ranking in (280) to account for the voicing patterns in Tamil.

(280) *Tamil ranking*

*VELARVOICE » NOSHORTVOICE » *LABIALVOICE, *ALVEOLARVOICE, IDVOICE

Since the markedness constraint against voiced velars dominates NOSHORTVOICE, intervocalic velars will not voice. However, segments at other places of articulation will voice since NOSHORTVOICE dominates *LABIALVOICE and *ALVEOLARVOICE. Geminates on the other hand pass the NOSHORTVOICE constraint making them immune to voicing.

Voicing in Tümpisa Shoshone affects all stops, but again not geminates. I propose that Tümpisa Shoshone has the ranking in (64), where all the relevant markedness constraints are ranked below NOSHORTVOICE.

(281) *Tümpisa Shoshone ranking*

NOSHORTVOICE » *VELARVOICE , *LABIALVOICE, *ALVEOLARVOICE, IDVOICE

Since *VELARVOICE is ranked below NOSHORTVOICE in this language, voicing will affect velars. The ranking of *LABIALVOICE and *ALVEOLARVOICE is the same as in Tamil. Alveolar and Labial segments voice in Tümpisa Shoshone as well.

We see that the small difference between Tamil and Tümpisa Shoshone with respect to the behavior of velars is captured through reranking of the relevant markedness constraints.

4.2.4 Conclusion

In this section I have shown how universal inalterability of geminates results from the failure of a markedness constraint to mark the geminate candidate. Since the failure to mark the candidate is a result of the internal structure of the constraint this type of inalterability is predicted to be universal. No language has geminates which show alterability with these phonological changes. In the next section I will discuss cases where the failure to mark is the result of forces external to the constraint, constraint domination. These are predicted to be non-universal.

4.3 Parochial Inalterability

Another logical possibility for explaining inalterability effects which I briefly consider for Tiberian Hebrew is constraint domination. In this scenario the result of changing a geminate in response to a markedness constraint produces a marked output. Therefore a higher ranked constraint blocks the effects of the ranking which would lead to alterability. This case I refer to as parochial inalterability since the prediction is that reranking of constraints could produce a language where geminates are alterable.

4.3.1 Latin lowering/deletion

Several historical changes in Latin involve the lowering or deletion of postvocalic glides. These changes all have in common that while they affect tautosyllabic vowel-glide sequences they do not affect heterosyllabic sequences. Furthermore, they fail to affect vowel-geminate glide sequences. I propose that onset glides are not affected because of the domination of the syllable markedness constraint ONSET. The same domination blocks these changes from affecting geminates.

Latin Diphthongs underwent the following changes from Archaic Latin to Classic Latin.

(282) *Lowering/Coalescence* Sommer and Pfister (1977)

Archaic Latin		**Classic Latin**
ay	→	ae
aw	→	
ey	→	iː
ew	→	ow
oy	→	uː / oe
ow	→	oe

There are two basic changes shown in (282). First, some glides are lowered following the back vowels *o* and *a*. Second, the front glide *y* merges with the mid vowels *e* and *o* and raises them to high vowels *i* and *u* respectively. I will ignore the rounding of *e* to *o* before *w* here. Both lowering and raising are restricted. They only apply if the vowel and the glide are tautosyllabic.

Lowering occurs only when the vowel and glide are tautosyllabic as shown in (283).

(283) *Lowering restricted to tautosyllabic sequences*

a. oy → oe

Old Lat. koyraaverunt 'take care-PERF-3pl' : koeraverunt	Class. kuuraaverunt
Old Lat. loydoos 'game-ACC pl' : loedoos	Class. luudoos
Greek poyna 'fine'	Class. poena
Greek øybalos 'a name'	Class. øebalus

b. ay → ae

Old Lat. ayde(m) 'house-ACC sg'	Class. aedem
Old Lat. aykwom 'equal-ACC sg'	Class. aekwum
Greek aynigma 'enigma'	Class. aenigma
Greek aysoopos	Class. aesoopus

Lowering does not take place when the glide is not tautosyllabic as the examples in (284) show.

(284) *Lowering blocked*

a.	/ai-is/	a.yis ~ a.is 'say-2sg'
b.	/ais/	aes 'bronze'
c.	co.i.tus ~ coe.tus ~ *co.e.tus	'meeting, union'

Furthermore, the glide *y* is geminated intervocalically in Archaic Latin. These geminate glides block the lowering as in (285).

(285) *Lowering blocked with geminates*

pey.yor	'worse'
may.yor, *mae.yor	'larger'
ay.yo, *ae.yo	'I say'
kuy.yos	'whose'
troy.ya, *troe.ya	Gk. troy.a
may.ya, *mae.ya	Gk. may.a
ay.yaks, *ae.yaks	Gk. ay.aks

Gemination is not productive in Classical Latin. However, geminates block lowering. The examples in (284) and (285) show that both geminate and onset glides fail to lower. The same is true of the contraction of mid vowels and glides.

Contraction occurs with tautosyllabic sequences as shown in (286).

(286) *Latin contraction*

a. ey → ii

Old Lat. deywos 'god'	Class. diiwus
Old Lat. deykerent 'say-SUBJ-IMPF-3pl'	Class. diikerent
Old Lat. keywis 'citizen'	Class. kiiwis

b. oy → uu

Old Lat. oytile 'useful'	Class. uutile
Old Lat. koyraaverunt 'take care-PERF-3pl'	Class. kuuraaverunt
Old Lat. oynus 'one'	Class. uunus

c. ow → uu

Old Lat. dowkit 'leads'	Class. duukit

Old Lat. lowkos	Class. luukus

However, contraction is blocked if the sequence is not tautosyllabic as in (287).

(287) *Contraction blocked*

a.	o.wis	'sheep'
b.	no.wa	'new-fem'

Contraction is also blocked if the *y* is a geminate as shown in (288).

(288) *Geminates fail to contract*

a.	peyyor	'worse'
	pompeyyus	
	eyyus	'that-GEN-sg'
	peyyeroo	'commit perjury'
b.	troyya	
	boyyae	'leather straps'
	koyyunks	'spouse'
	hoyyus, later huyyus	'this-GEN-sg'

Again we have the pattern where the change occurs only when the two segments are completely tautosyllabic.

I propose that the active constraint which is forcing the change in Latin is a markedness constraint against glides.

(289) *Constraint Set*

IDENTHIGH Input and output correspondents agree in high features.

IDENTROUND Input and output correspondents agree in round features.

*GLIDE Do not have a glide.

ONSET Syllables have onsets.

The two IDENT constraints demand featural identity between input and output correspondents. The ONSET constraint is a syllable markedness constraint which militates against onsetless syllables.

With *GLIDE ranked above IDENTHIGH and IDENTROUND, coalescence of the dislike segments will be optimal in order to avoid the *GLIDE violation.

(290) **GLIDE » IDENTHIGH, IDENTROUND, from tautosyllabic sequences*

/$o_1y_2$tile/		*GLIDE	IDENTHIGH	IDENTROUND
a.	.o_1y_2.ti.le.	*!		
b. ☞	.$uu_{1,2}$.ti.le.		*	*

Candidate (b) avoids the markedness constraint by coalescing the two segments. Coalescence violates IDENTHIGH since the mid vowel in the input corresponds to a high vowel in the output. Coalescence also violates IDENTROUND since the non-round glide in the input corresponds to a round vowel in the output. I will ignore the length of the resulting vowel here. Coalescence occurs to alleviate the *GLIDE violation despite the faithfulness violations involved.

When the two segments are not tautosyllabic, ONSET blocks the effects of this ranking.

(291) *Onsets fail to coalesce: ONSET » *GLIDE*

/no_1w_2a/		ONSET	*GLIDE	IDENTHIGH	IDENTROUND
a.	$nuu_{1,2}$.a	*!			
b. ☞	no_1.w_2a		*		
c.	$nuu_{1,2}$.w_2a		*	*!	*!

Complete merger of the two segments, candidate (a), leaves the second syllable onsetless. This fatally violates ONSET. Candidate (c) with partial merger is ruled out since it fails to alleviate the markedness constraint while also violating faithfulness. Therefore merger is blocked when the two segments are not tautosyllabic.

This ranking also accounts for the lack of merger with geminates. ONSET again blocks the effects of the merger ranking.

(292) *Geminate blockage*

/e_1yy_2us/		ONSET	* GLIDE	IDENTHIGH	IDENTROUND
a.	$ii_{1,2}.us$	*!			
b. ☞	$e_1y.y_2us$		*		
c.	$ii_{1,2}.y_2us$		*	*!	

As in (291), ONSET blocks complete merger, candidate (a). Again, candidate (c) with partial merger, is ruled out since it violated faithfulness without alleviating the markedness violation. Therefore, the *GLIDE violation is tolerated.

4.3.2 Conclusion

Here is a case where a higher ranked constraint blocks the process from applying to the geminate. Important here is the fact that the ranking responsible for blocking the process from applying to geminates also blocks it from applying to onsets. This analysis predicts that there are two possible language types. One language is of course Latin with coalescence in codas and not in onsets or with geminates. The other language would have coalescence across the board, in codas, onsets and geminates. This language results if ONSET is ranked below the markedness constraint against *GLIDE. I have been unable to find such a language. However, this analysis does not take into account moraic faithfulness constraints. The discussion of geminates and coda restrictions in the next section is relevant here. Therefore, there may be other reasons that such a language does not exist.

4.4 Coda Restrictions

It is a well known fact that many languages place restrictions on the types of possible codas. It is also well known that geminates are typical exceptions to coda restrictions. For example a language may not allow oral stops as codas, but still allows geminate oral stops. Typically a ban on codas is enforced by either deletion of the offending segment or insertion of an epenthetic vowel to reparse the offending segment as an onset. In this section I will argue that geminates do run afoul of coda restrictions, but that the valid repair for a geminate involves a different faithfulness breach than that of a singleton, degemination as opposed to insertion or deletion. Therefore, different rankings of faithfulness constraints account for the exceptional behavior of geminates.

In order to maintain the separate repair for geminates, epenthesis and deletion cannot be possible repairs for geminates. I will argue that the moraic theory of geminates predicts this result.

The analysis presented here works on the hypothesis that so-called coda restriction reflect the interaction between a general NOCODA constraint and specific markedness and faithfulness constraints rather than constraints of the type ‘no codas except place assimilated nasals and geminates.’

4.4.1 Geminates and NOCODA

With respect to geminates and coda consonants, languages form three possible types. A language may have both coda consonants and geminates (for example the Scandinavian languages; Swedish, Danish, Norwegian, etc.), or only coda consonants and no geminates (English, French, etc.) or only geminates and no coda consonants (Woleaian and Luganda).[42] This typology

[42] Often geminates are grouped with homorganic nasal-stop clusters as exceptions to coda conditions (see Itô 1986, Itô and Mester (1994)). The grouping is understandable since both exceptions can be classified as place linked to a following onset. However, Sherer (1994) shows that the existence of geminates or homorganic nasal-stop clusters cross-classifies. So, Woleaian and Luganda have geminates but not homorganic nasal-stop clusters while Gumbaynggir has nasal-stop clusters but no geminates.

follows from the moraic theory of geminates and the faithfulness constraints on moraic association proposed above.

I will assume the very general constraint NoCoda as given in (293) (Itô 1986, Prince and Smolensky 1993).

(293) *NoCoda constraint*

NoCoda Syllables do not have codas.

A coda is defined as any post-vocalic consonant which is in the same syllable as the preceding vowel. I assume, as above that, codas may be moraic or nonmoraic depending on the relative rankings of constraints in the language. Importantly, moraic consonants are necessarily codas.

It is clear from this definition that geminates violate NoCoda. In Moraic theory, underlying geminates are moraic. Geminates surface as both codas and onsets due to constraints on syllabic well-formedness. The general input-output mapping for geminates is given in (294).

(294) *Input-output mapping for geminates*

In the surface representation in (294), the geminate is parsed as both an onset and a coda. The markedness constraint Onset forces the geminate to be parsed as an onset. Faithfulness to the underlying moraic association of *t* forces it to be parsed as a coda. The coda parsing occurs despite the fact that it incurs a NoCoda violation. Therefore, in order for a language to have geminates, NoCoda must be dominated by all faithfulness constraints to the underlying moraic association of the consonant.

The relevant moraic faithfulness constraints are repeated here from Chapters two and three.

(295) *Moraic Faithfulness*

Max-μ_{S1-S2}

Every mora in S_1 has a correspondent in S_2.

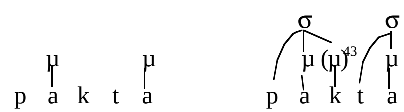
Max-Association

If m_1 is a mora in the input and it is associated to s_1 and $m_1\Re m_2$, and $s_1\Re s_2$ then m_2 is associated to some s_2.

These faithfulness constraints regulate the input output mapping of moras and associated segments. The constraint Max-μ militates against deletion of moras. The constraint Max-Association militates against moving the mora from its underlying associated segment.

In contrast, an underlying consonant cluster leads to a surface NoCoda violation in a much different way. Consider the input-output mapping for the cluster *kt* in (296).

(296) *Input-output mapping for consonant clusters*



There is nothing about the underlying representation of *k* in (296) which necessitates it being parsed as a coda. It is only the relative position of *k* to *t* that forces the coda parsing in (296). But even this relation can be avoided in a faithful parse of the cluster. For example, the cluster could just as well form a complex onset to the following syllable. Therefore in order for a language to have coda consonants of this type, the faithfulness constraints against consonantal deletion and vocalic epenthesis and the markedness constraint against complex onsets must dominate NoCoda.

The constraints that are relevant for the coda parse of the first consonant in a cluster are given here in (297).

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[43] Whether the coda consonant is moraic or not will depend on the interaction of constraints that favor moraic codas (ex. Weight-By-Position) with constraints against moraic codas (ex. Depμ).

(297) *Cluster constraints*

MAX	Every element of S_1 has a correspondent in S_2.
DEP	Every element of S_2 has a correspondent in S_1.
*COMPLEX	No more than one segment may associate to a syllable position.

The faithfulness constraint MAX requires that all segments of the input have a correspondent in the output. It is violated by literal deletion of an output segment. MAX forces the coda parse of the first member of a cluster since it marks any candidate where one of the members of the cluster has been removed, leaving a single onset. The constraint DEP on the other hand requires that all segments in the output have a correspondent in the input. It is violated by insertion of segments in the output. DEP forces the coda parse of the first member of a cluster since it marks any candidate which contains an epenthetic vowel which provides an extra syllable and thus an extra onset position for the offending consonant. Finally, the markedness constraint *COMPLEX militates against onsets (as well as codas) with more than one segment. *COMPLEX forces the coda parse of the first member of a cluster since it rules out any candidate where both consonants are parsed as a complex onset to the following syllable. Given these constraints, it is clear that in order for a language to have surface codas, all three constraints must dominate NOCODA.

An important question is whether the same constraints that are relevant for singleton segments can also be relevant for geminates. That is, can a language have NOCODA dominating *COMPLEX, DEP or MAX and thus avoid both cluster codas and geminate codas. The answer is no. I will begin by showing that NOCODA » DEP is insufficient to eliminate geminates from the surface.

4.4.1.1 Geminates and epenthesis

A well known property of geminates is that they have integrity. That is, no epenthetic process splits geminates into a sequence of like consonants

surrounding the epenthetic vowel. I propose that this fact follows from the Moraic Theory of geminates and the constraints on prosodic faithfulness and prosodic markedness. I will show that the interaction of the markedness and faithfulness constraints above, NOCODA, and those in (296) and (297), will never force epenthesis into a geminate. In each case there is always an alternative candidate that harmonically bounds the epenthetic candidate. That is, it satisfies the markedness constraint and is more faithful to the input. Therefore epenthesis will never be optimal given a geminate input.

First of all, epenthesis by itself will not alleviate the NOCODA violation caused by a geminate. Since geminates become surface codas because of their underlying association to a mora, epenthesis into a geminate will just recreate the geminate in a different syllable. MAXμ demands that at least one mora in the output corresponds to the input mora. MAXASSOCIATION also demands that the output mora be associated to at least one of the output segment correspondents. Therefore to avoid violating Maxμ and MAXASSOCIATION, one of the fissioned output correspondents must have a mora associated to it. The example in (298) shows a fissioned output mapping[44].

(298) *Epenthesis into a geminate*

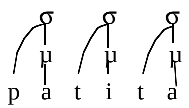
The fissioning of the geminate in this case does not alleviate the NOCODA violation because there is still one segment that is a geminate as demanded by the moraic faithfulness constraints. The only option is epenthesis with degemination.

Epenthesis with degemination is overkill with respect to the NOCODA violation. Consider two possible alternative candidates.

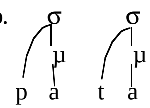
[44] The choice of which segment reatains the mora assocaition is arbitrary. Another possible candidate with the same problems reverses this choice.

(299) *Satisfy NOCODA*

a.



b.



In candidate (a) a vowel is epenthesized into the geminate, and the geminate is degeminated. NOCODA is satisfied. In candidate (b), the geminate is only degeminated. Again, NOCODA is satisfied. Both candidates in (299) are unfaithful to the underlying mora. However, the candidate in (a) violates DEP as well and also increases segmental markedness since it fissions the geminate.

Both candidates in (299) share the same moraic faithfulness violations. Given the correspondence theory of moraic faithfulness advanced here, there are two possible ways to degeminate. Either the mora association to the underlying geminate is deleted, or the mora is reassociated to some other segment. The choice between these two possibilities in a particular language is the result of the relative ranking of MAXμ and MAXASSOCIATION. If MAXASSOCIATION dominates MAXμ then degemination will be deletion of the mora. If MAXμ dominates MAXASSOCIATION then degemination will be reassociation of the mora. I will show that with either ranking, candidate (b) always harmonically binds candidate (a).

Suppose MAXμ is the lowest ranked of the moraic faithfulness constraints. Therefore degemination means deletion of the mora associated to the geminate. In both candidates, the underlying mora associated with the geminate is deleted. Therefore both candidates violate MAXμ. However, candidate (b) will be universally preferred to candidate (a) since it avoids the DEP violation.

(300) *No Epenthesis with fission*

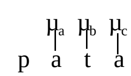
/pat$^{\mu}$a/	NOCODA	MAXASSN	MAXμ	DEP
a. ✘ .pa.ti.ta.			*	*!
b. ☞ .pa.ta.			*	
c. .pat.ta.	*!			
d. ✘ .pa.ti.ta.		*!		*
e. .pa.ta.		*!		

Candidates (d) and (e) are the reassociation candidates (see (301) below). Both of these are ruled out by the ranking of MAXASSOCIATION above MAXμ. Candidate (c) is the faithful candidate which violates NOCODA. The two remaining candidates (a) and (b) both violate MAXμ since they delete the mora associated with the geminate. Candidate (a), with fission and epenthesis, is harmonically bounded by candidate (b). It has the same MAXμ violation as (b) and also violates DEP since it has an epenthetic vowel. In order to get rid of candidate (c), NOCODA must dominate MAXμ. The relative ranking of DEP is not determined by this competition. Tableau (300) shows that NOCODA can only force degemination of an underlying geminate, it cannot force epenthesis with fission.

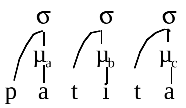
Suppose degemination is represented by reassociation of the mora to another output segment. Therefore, MAXASSOCIATION is the lowest ranked of the moraic faithfulness constraints. The examples in (301) show the two relevant candidates.

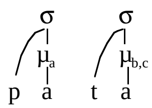
(301) *Reassociation to another segment*

Input:



Outputs:

a. 

b. 

In candidate (a), the mora associated to the geminate underlyingly, μ_b, is associated in the output to the epenthetic vowel. In candidate (b), the mora associated to the geminate underlyingly is fused with the following mora, $\mu_{a,b}$. Under the assumption that such fusion of moras only violates MaxAssociation, these two candidates share the moraic faithfulness violations. Therefore, as above, candidate (b) will be preferred to candidate (a) universally.

(302) *No Epenthesis with fission*

/pat$^\mu$a/	NoCoda	Maxμ	MaxAssn	Dep
a. ✘ .pa.ti.ta.			*	*!
b. ☞ .pa.ta.			*	
c. .pat.ta.	*!			
d. ✘ .pa.ti.ta.		*!		*
e. .pa.ta.		*!		

In this tableau, candidates (d) and (e) are the deletion candidates. They both violate Maxμ which is fatal since Maxμ dominates MaxAssociation in this language. Candidate (c) is the faithful geminate candidate, with the NoCoda violation. Candidates (a) and (b) are the reassociation candidates. Again, candidate (a) is harmonically bounded by candidate (b). Both candidates share a MaxAssociation violation, while candidate (a) has an extra Dep violation. If NoCoda dominates MaxAssociation, the optimal candidate is the one that violates only MaxAssociation.

Tableaux (300) and (302) show that NoCoda can only force degemination, it cannot force epenthesis with fission. No matter how you reckon the moraic faithfulness violation, either as deletion or fusion, there is always a more faithful candidate that harmonically bounds the epenthesis

candidate. Therefore epenthesis is not a possible repair for geminates as it is for singletons.

4.4.1.2 Deletion and complex parsing

In this section I discuss the two other possible repairs for a consonant cluster input, deletion and complex parsing. I will show that both of these are also not possible repairs for geminate inputs. Segmental deletion fails for a geminate input for the same reasons that epenthesis fails for these inputs. Deletion of the segment is overkill, it is more than is required to meet the NoCoda constraint. Parsing the geminate as a complex onset is not a possible repair because doing so violates inviolable constraints on the construction of syllables.

Deletion of a segment in a consonant cluster follows from ranking NoCoda, *Complex and Dep above Max. The tableau in (303) shows the effect of this ranking on an input cluster.

(303) *Deletion of C_1*

/$p_1a_2k_3t_4a_5$/	NoCoda	*Complex	Dep	Max
a. ☞ .p_1a_2.t_4a_5.				*
b. .$p_1a_2k_3$.t_4a_5.	*!			
c. .p_1a_2.$k_3t_4a_5$.		*!		
d. .p_1a_2.k_3i.t_4a_5.			*!	

The optimal output deletes the *k* and thus avoids the NoCoda violation.[45] Epenthesis and onset formation are ruled out by the higher ranked Dep and *Complex. Since the *k*is not associated to any mora in the input, the moraic faithfulness constraints are not relevant to this input. This situation contrasts with that of the geminate, where moraic faithfulness issues are unavoidable.

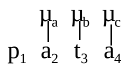
With a geminate input, deletion of the segment leads to either a Maxμ violation or a MaxAssociation violation since the mora is associated to that

[45] Deciding which consonant to delete is not trivial issue. I will assume that a solution exists.

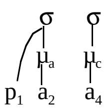
segment in the input.[46] Deletion also creates an ONSET violation since the geminate is only one segment inter-vocalically. The example in (304) shows two output candidates for a geminate input. Both candidates have deleted the segmental material of the geminate.

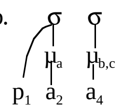
(304) *Deletion of a moraic segment*

Input:



Outputs:

a. 

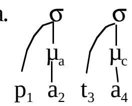
b. 

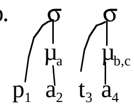
As is evident from the candidates (a) and (b), deletion of the geminate segment creates two problems. First, since the geminate is mono-melodic, deletion leads to an ONSET violation. Both candidates violate ONSET. Second, the question of the input mora arises. Candidate (a) simply deletes the mora as well as the segment. Deletion of the mora violates MAXμ. Candidate (b) on the other hand, reassociates the mora to the following vowel. Reassociation violates MAXASSOCIATION.

As for the epenthesis cases above, there are competing candidates where the geminate is simply degeminated. These candidates have the advantage over those in (304) since they do not violate ONSET or MAX. For example, the candidate in (305a) violates MAXμ but satisfies ONSET and MAX, while the candidate in (305b) violates MAXASSOCIATION but satisfies ONSET and MAX.

[46] I assume that inviolable constraints on syllable construction proclude deleting the segment and allowing the mora to float.

(305) *Degemination*

a. 

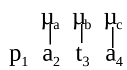
b. 

The degemination candidates in (305) are universally preferred to the degemination plus segmental deletion in (304) since they entails a subset of the violations of those candidates. Just as degemination and epenthesis was dispreferred compared to simple degemination, degemination with deletion is dispreferred compared to simple degemination.

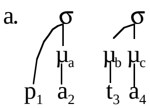
The final repair strategy for the consonant cluster is parsing the cluster as a complex onset. Complex onset parsing is impossible for geminate inputs due to undominated constraints against syllable formation that precludes a mora being parsed as an onset.

(306) *Complex parsing*

Input:



Output:

a. 

The representation in (306a) is impossible because the mora cannot form a part of the onset. Therefore, parsing the geminate as a complex onset is impossible.

In this section I have shown that both segmental deletion and parsing the geminate as a complex onset are not possible repairs to avoid the NOCODA violation caused by geminate outputs. The impossibility of these repairs follows form both the representational assumptions about geminates and the way the constraints evaluate those representations, particularly the faithfulness constraints to moraic structure.

In the preceding discussion I looked at the constraint NoCoda, which is a very general constraint banning codas. I have shown that this general constraint can give us a typology of four languages when interacting with the moraic faithfulness constraints in (295) and the segmental constraints in (297). One group of languages allow both segmental codas and geminate codas. In these languages all the moraic faithfulness constraints and segmental constraints dominate NoCoda. Languages that fit this type are the Scandinavian languages like Swedish and Norwegian. A second group of languages allows neither geminates or segmental codas. In these languages NoCoda dominates some moraic faithfulness constraint and some segmental constraint. Languages of this type include Samoan, etc. A third group of languages allows geminates but not segmental codas. In these languages NoCoda dominates some segmental constraint but is dominated by all moraic faithfulness constraints. Languages of this type include Woleaian and Luganda. The fourth and final group of languages allows segmental codas but not geminates. In these languages NoCoda dominates some moraic faithfulness constraint but is dominated by all segmental constraints. Languages of this type include English. The actually typology of languages is somewhat more complicated than that just presented in that some languages allow codas but only of certain kinds. I will discuss languages like this briefly in the next section.

4.4.1.3 Coda constraints

Some languages put extra restrictions on what are possible codas in the language. That is, they allow codas but only of some unmarked type, for example coronals (Lardil) or place assimilated nasals (Japanese and Ponapean). In this section I will briefly discuss these types of restrictions and their relation to the exceptionality of geminates.

There are two types of proposals in the OT literature about exceptions to the NoCoda restriction. One type of analysis is to posit constraints like CodaCond which explicitly ban codas except for unmarked ones.

(307) *The Coda Condition* Prince & Smolensky (1993: 99)

CodaCond A coda consonant can have only Coronal place or else no place specification of its own at all.

CodaCond constraints are in the grammar either in addition to or in place of the monolithic NoCoda. A second approach is to view coda restrictions as violations of NoCoda due to higher ranked constraints. For example, Beckman (1997) argues that the fact that place assimilated nasals are exceptions to NoCoda can be accounted for by the interaction of place markedness constraints and NoCoda. The key claim is that place assimilated nasals reduce place markedness since two segments share one place feature. On the other hand, epenthesis into such a cluster increases place markedness since both consonantal must have their own place specifications (there is no place sharing across a vowel). Therefore, if place markedness dominates the NoCoda over Dep ranking, epenthesis will be blocked. Although her particular solution is problematic (as discussed below) this idea is good because it exploits the nature of OT, the interaction of ranked and violable constraints. This type of blocking ranking schema is how I account for the geminate exceptionality above.

The crucial idea in a blocking schema is that some clusters are less optimal than their non-cluster counterparts. For example, in the case of assimilated nasal clusters, an NC cluster is more optimal than the sequence NVC. Therefore, we posit a constraint that prefers NC to NVC (i.e. NC $\succ$ NVC). If that constraint dominates the NoCoda » Dep ranking, epenthesis will be blocked if it leads to the more marked nasal structure. Therefore, nasal clusters are exceptions to the “no coda” requirement of the language. This is the same idea as having Maxμ dominate the NoCoda » Dep ranking for geminates above.

The important question is, what is the nature of the NC $\succ$ NVC constraint. There are two ways to think of this constraint. One is to assume that NC is more optimal than NVC universally, so that there is a surface markedness constraint which prefers NC to NVC. For example, in Beckman's (1997) analysis, NC can share place and thus reduce the markedness violations so the constraint *PLACE prefers NC to NVC (i.e. one versus two place violations). The second is to assume that NC is preferred to NVC relative to NC inputs only. So that there is a faithfulness constraint which dislikes epenthesizing into NC clusters for example.

The markedness approach gives a strange typology and therefore is dispreferred. The markedness constraint NC ≻ NVC can interact with MAX for example causing all /NVC/ inputs to surface as NC, forcing deletion of the inter-cluster vowel. That is, producing a language which only has nasals in codas. In this language all nasals before vowels (onsets) are neutralized to NC clusters on the surface. This is an odd prediction and one which is not realized in any language. Because of this problem, I believe that the NC ≻ NVC constraint must be a faithfulness constraint and not a markedness constraint.

As a faithfulness constraint, NC ≻ NVC prefers the surface NC cluster only when there is an NC cluster in the input. It therefore does not have the problem of a markedness constraint which can force /NVC/ inputs to neutralize to NC outputs. With geminates the faithfulness constraint responsible for blocking neutralization was one of the moraic faithfulness constraints. Unfortunately, for NC cluster, there is no clear faithfulness constraint that can do the trick. One possibility is to stipulate something about the input nature of NC clusters, for example the nasal in such clusters is always moraic, or that they always share place in the input. Both of these solutions are untenable though both for theoretical reasons and for empirical reasons. Theoretically, both analyses go against richness of the base. Empirically, it is true that for example languages can independently allow either geminates or nasal clusters as exceptions (Woleaian vs. Spanish). Therefore these cannot be due to the same moraic faithfulness constraint. Also, some languages allow both place assimilated NC clusters and non-place

assimilated clusters. If all NC clusters shared place in the input, then languages could not make this distinction. The exact formulation of the faithfulness constraint remains then a subject of future research.

The benefit of analyzing NOCODA exceptions through constraint interaction is two-fold. First geminates and other NOCODA exceptions are treated in the same way. Second, we do not have constraints like NOCODA and NOCODA except NC, etc. but rather such effects achieved through constraint ranking, the core aspect of OT (Prince 1997).

*4.4.2 Geminates and *COMPLEX*

Finally, the fact that geminates are not split by epenthesis carries over to epenthesis due to *COMPLEX violations. I will discuss this behavior in this section. Ultimately geminates resist epenthesis due to *Complex violations for the same reason as they resist epenthesis from NOCODA, epenthesis simply doesn't solve the problem. I will examine the case of Palestinian Arabic mentioned in chapters two and three above.

Palestinian Arabic (Abu-Salim 1980, Hayes 1986) is an example of an epenthesis process driven by the constraint *COMPLEX. As I discussed in chapter two, epenthesis occurs in Palestinian Arabic to break up consonant clusters at the end of the word or medially when they are longer than two consonants.

(308) *Epenthesis into CC clusters in Palestinian Arabic* (Hayes 1986)

a. /ʔakl/	→	ʔakil	'food'
b. /ʔakl kum/	→	ʔakilkum	'your food'
c. /jisr kbiir/	→	jisrikbiir	'big bridge'

Consonant clusters at the end of words, as in (a), are broken up by the epenthetic *i*. Furthermore, medial clusters which are greater than two consonants in length are also broken up with the epenthetic vowel, as in (b and c). Since clusters two segments long are possible, we know that

NOCODA is violable in the language. The constraint driving epenthesis must be *COMPLEX as discussed above.

In contrast to consonant clusters, geminates are allowed in Palestinian Arabic finally and as the initial member of a medial consonant cluster.

(309) *No epenthesis into tautomorphemic geminates*

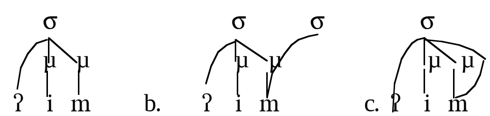
a. /ʔimm/ → ʔimm, *ʔimim 'mother'

b. /sitt na/ → sittna, *sititna 'grandmother'

Epenthesis does not break up geminates which shows that they are not represented the same way as consonant clusters.

In order to understand the proposal here we must consider the representation of final geminates. There are three possibilities, given here in (310).

(310) *Final Geminates*



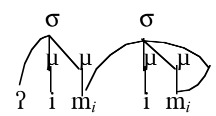
In (310a) the final geminate is represented as simply a moraic coda. Under this proposal, non-geminate final consonants would be represented as non-moraic codas. Length would be the phonetic interpretation of moraicity. In (310b) and (310c), final geminates are represented as medial geminates, with multiple linking. In (310b) it is linked to a degenerate syllable. In (310c) the geminate segment is linked to the final syllable. Regardless of the choice in representation, the failure of epenthesis is captured. If we choose (310b or c) then there must be some Faithfulness constraint that forces the second link to the syllable node.

The constraint *COMPLEX is formalized so that it dislikes branching syllable nodes. Therefore, two of these representations predict no epenthesis. The representations in (310a) or (310b) pass the *COMPLEX constraint since

their codas do not branch. In that case, there is no pressure to epenthesize and so there is no epenthesis. The representation in (310c) will fail the constraint since the coda branches.

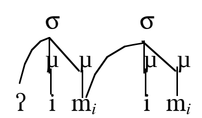
However, *COMPLEX still will not force epenthesis in (310c). Epenthesis fails because it does not alleviate the problem. As I mentioned above, if we assume this representation, some faithfulness constraint must be forcing the final link to the syllable. Epenthesis with fusion of the geminate (epenthesis *into* a geminate) only recreates the complex coda in another syllable since both of the split geminates must be faithful in the same way. Epenthesis of a vowel and copying of the geminate is shown in (311).

(311) *Epenthesis into a final geminate*



The offending structure in (311) is merely recreated in another syllable. The representation in (311) still violates *COMPLEX. Therefore, epenthesis is not a possible repair for final geminates. Possible repairs for final geminates under these structural assumptions include degemination, and post geminate epenthesis. Both of these candidates avoid the marked structure.[47] Another possible candidate is one with epenthesis into the geminate but degemination of the final consonant.

(312) *Epenthesis into a final geminate with degemination*



[47] Turkish (Clements and Keyser 1983) degeminates final geminates where it epenthesizes into final consonant clusters.

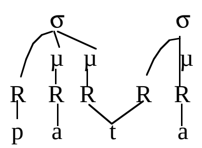
The candidate in (312) violates the faithfulness constraint is responsible for the existence of final geminates in addition to DEP. Therefore it will be harmonically bounded by a candidate with epenthesis only (i.e. ʔimmi).

Regardless of the choice of representation for final geminates in (310), the moraic theory predicts that final geminates will not be split by epenthesis. If the moraic representation satisfies the constraint driving epenthesis, epenthesis is overkill. If, the moraic representation violates the constraint driving epenthesis, epenthesis fails to repair the violation.

4.4.2.1 Two-root theory

The two-root theory of geminates cannot capture the failure of epenthesis with respect to geminates in way the moraic theory does. The two-root theory treats geminates the same as consonant clusters. The example in (313) shows a two root representation for a geminate.

(313) *Two-root geminate*



At the root level a geminate looks exactly like a consonant cluster. Furthermore, there is no prosodic faithfulness that is relevant for two-root geminates, since their length is the result of the number of root nodes, and not their prosodic affiliation. Therefore, epenthesis fissioning geminates driven by markedness constraints is expected.

For example, take the problem with NOCODA. Given a two-root input, no Faithfulness constraints can block epenthesis.

(314) *No Faith for two-root theory*

/patti/	NOCODA	DEP
a. .pat.ti.	*!	
b. ☞ .pa.ti.ti.		*

Since there are no prosodic Faithfulness constraints at work with two-root geminates, candidate (b) is optimal. A possible solution to this problem is to introduce a NO SPLITTING constraint. However, any constraint against splitting would have to be ranked above NOCODA universally in order to prevent reranking from favoring the split candidate.[48]

4.4.3 Conclusion

In this section I have discussed the behavior of geminates with respect to constraints on codas. In some sense these effects fit under the rubric of geminate inalterability, since geminates are not split by epenthesis when consonant clusters are. Under this view, geminates are 'exceptions'. Previous analysis of these facts have built geminate exceptionality into the rule or constraint. However, from the OT perspective, we can see that geminates are not necessarily exceptional. What sets geminates apart from consonant clusters is the types of repairs that work for consonant clusters do not work for geminates. The reasons for this are the different representations of the two phenomena and the way that constraints, particularly faithfulness constraints interact with these representations. This perspective also treats geminates as alterable in these contexts. They are just not alterable in the same ways as consonant clusters.

[48] Or the constraint would have to be universally inviolable as the No Crossing Association lines constraint in autosegmental theory.

5. Residual Issues and Conclusion

5.1 Residual issues

In this section I would like to address two residual issues. Both issues deal with the OCP. There are some remaining issues with respect to the lexical OCP that need to be discussed. Furthermore, I have not discussed the surface OCP. In section one I will discuss the lexical OCP effects in Arabic roots. I will show that these effects do not require the appeal to an OCP constraint. In section two I will discuss antigemination effects. These efects also seem to be amenable to a solution that does not require an OCP constraint.

5.1.1 The Lexical OCP and Arabic Roots

I have discussed the Lexical OCP proposal of McCarthy (1986) with respect to geminates in Chapter two. McCarthy (1986) also uses the Lexical OCP to capture restrictions on so-called long distance geminates.

In Arabic (McCarthy 1979, 1981) roots are underlying sequences of consonants, which are mapped onto prosodic templates. The examples in (315) provide some examples of forms I through IV.

(315) *Arabic Roots*

	Perfective		
	Active	*Passive*	
I	katab	kutib	'write'
II	kattab	kuttib	'cause to write'
III	kaatab	kuutib	'correspond'
IV	?aktab	?uktib	'cause to write'

The root for the verb 'write' appears to be made up of the three consonants *ktb*. These consonants are arranged in a template for each of the forms (I through IV). The template remains constant for each of the forms, that is it

does not change depending on the verb root or the tense. For example the template for form III is a CVVCVC template. For the root 'write' *ktb*, the template is realized as either *kaatab* 'active' or *kuutib* 'passive'.

In some forms the final root consonant is spread over two consonant slots as in (316).

(316) *Perfective Active*

IX ktabab

In this form, the template is CCVCVC. There are not enough root consonants to fill all the consonant slots in the template. Therefore, the final consonant plays double duty in two of the consonant slots.

Whereas the majority of Arabic roots are triconsonantal with patterns like those in (315) and (316), there are also roots that always surface in forms like (317) where the final two root consonants are identical.

(317) *Perfective Active*

I samam

The difference between *samam* and *katab* is that in samam the final two consonants have the same melodic quality where in *katab* they are different. However, the template for the form is exactly the same, CVCVC.

McCarthy (1986) provides evidence that roots like those in (317) are underlyingly bi-literals. That is, the form in (317) comes from /sm/ and not /smm/. The evidence is threefold. First, there are no forms of the type **sasam*, where the first two consonants have the same melody. This surface restriction is captured elegantly if we assume that the OCP applies in the lexicon, effectively banning /ssm/ and /smm/. In addition association of melodies to the template proceeds from left to right. In this way, underlying /sm/ will surface as *samam* and not **sasam*. Second, Manipulation of roots in language games and reduplication treat the multiple final consonants as a single melody (McCarthy 1982, 1985). This is captured straightforwardly if these processes act on the lexical root and not the surface form. Finally, in other languages phonological changes may overapply to long-distance geminates as in Chaha. If these processes apply before the surface form, overapplication is predicted. Therefore McCarthy argues that these facts support the hypothesis that the OCP applies to lexical representations.

My proposal regarding the lexical OCP works well for pair geminates, which are adjacent in the representation. However, long-distance geminate effects are not captured in my proposal. To show this I will sketch a simple analysis of Arabic templatic morphology.

5.1.1.1 Templatic Morphology

Suppose that in a language with templatic morphology, Markedness constraints on the alignment between morphology and prosodic structure as well as prosodic Markedness constraints are more important than faithfulness to linear order of consonants and vowels. Under this view, templatic morphology is an Emergence of the Unmarked effect (see McCarthy & Prince 1994, Sharvit 1994).

To account for the templates we must account for the general shapes of the templates, as well as the particular templates associated with the Forms. All the templates are bisyllabic and end in a consonant. A reasonable assumption is that Roots must be prosodic words. Alignment constraints like those in (318) will enforce the size restriction.

(318) *Alignment restrictions*

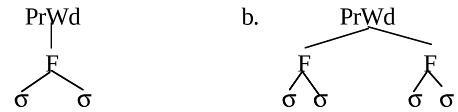
ALIGN(Root, L/R, PrWd)

ALL-FEET-LEFT Feet are leftmost in the prosodic word.

ALL-FEET-RIGHT Feet are rightmost in the prosodic word.

The constraints in (4) accounts for the fact that all roots are maximally bisyllabic and minimally bimoraic, since this template meets all the alignment requirements. A prosodic word consisting of a single foot satisfies all the alignment constraints as in (319).

(319) a. b.



✔ALL-FEET-LEFT *ALL-FEET-LEFT

✔ALL-FEET-RIGHT *ALL-FEET-RIGHT

The form in (319a) with a single F is the optimal PrWd from the point of view of the alignment constraints. More feet only results in the violation of the alignment constraints.

In addition to the size restriction we see that all the templates end on a consonant. If ALIGN(Root, R, PrWd) dominates the constraint dominates NOCODA then we can explain this aspect of the template under the assumption that the vowels are not part of the root, but are associated with the tense affix.

(320) ALIGN(Root, R, PrWd)» NOCODA

	ALIGN(Root, R, PrWd)	NOCODA
a. ☞ ...$C]_{PrWd}$		*
b. ...$V]_{PrWd}$	*!	

Since ALIGN(Root, R, PrWd) is violated by the vowel final form, candidate (a) is preferred.

Given these constraints, a simple LL template such as the one in Form I has three consonant slots. Two onsets (one for each syllable) and one coda forced by ALIGN(Root, R, PrWd). The tableau in (321) shows that this template is optimal.

(321) /ktb/ + /a/ ↦ [|#ka.tab#|] (I)

	ALL-FEET-LEFT/RIGHT	ONSET	ALIGN(ROOT, LR, PRWD)	NOCODA
a. ☞ katab				*
b. aktab		*!	*!	*
c. katba			*!	*

The optimal way of arranging the consonants into this template is candidate (a), the CVCVC template. This template satisfies all the alignment constraints as well as the markedness constraint ONSET.

In order to account for the biliteral roots we must posit one further constraint that disprefers identical adjacent segments root initially. As McCarthy notes, there are no roots with initial adjacent identical segments. In McCarthy's system this follows from the direction of association. I propose the following alignment constraint which has the effect of directionality.

(322) *Segmental Alignment*

ALLSEG-LEFT All segments in the root must be anchored on the left edge of the PrWd.

Clearly this constraint needs more development, however it will do for the purposes of this discussion. ALLSEG-LEFT is violated by each root segment that is not on the left edge of the prosodic word. A violation is assesed for each segment that intervenes between the first correspondent of a misaligned segment and the left edge.

With ALLSEG-LEFT dominant in the language, roots of the type /ssm/ will be blocked from surfacing faithfully. Instead they will neutralize to *samam*.

(323) /$s_1s_2m_3$/ + /a/ ↦ [|#sa.mam#|] (I)

	ALLSEG-LEFT	ALL-FEET-LEFT/RIGHT	ONSET	ALIGN(Root, LR, PrWd)
a. ☞ $s_{1,2}am_3am_3$	**			
b. $s_1as_2am_3$	******!			

Since coalescence of the two *s*'s and fission of the *m* does not violate featural faithfulness candidates (a) and (b) tie with respect to those constraints. Both candidates also meet the templatic requirements of ALL-FEET-LEFT/RIGHT, ONSET, and ALIGN(Root, LR, PrWd). Therefore, only the ALLSEG-LEFT constraint decides between them.

This grammar also gives the same phonetic output given the inputs /sm/ and /smm/. The tableau in (324) and (325) show this.

(324) /s_1m_2/ + /a/ ↦ [|#sa.mam#|] (I)

	ALLSEG-LEFT	ALL-FEET-LEFT/RIGHT	ONSET	ALIGN(Root, LR, PrWd)
a. ☞ $s_1am_2am_2$	**			
b. $s_1as_1am_2$	****!			

(325) /$s_1m_2m_3$/ + /a/ ↦ [|#sa.mam#|] (I)

	ALLSEG-LEFT	ALL-FEET-LEFT/RIGHT	ONSET	ALIGN(Root, LR, PrWd)
a. ☞ $s_1am_{2,3}am_3$	**			
b. $s_1am_2am_3$	******!			
c. $s_1as_1am_{2,3}$	******!			

Both the inputs /sm/ and /smm/ will surface as *samam* in this grammar. Again, this form optimally satisfies the constraints responsible for the template. Also, the optimal form of (325) has a long distance geminate rather than one to one mapping of input segments to output segments.

This analysis of long distance geminates treats them as a type of reduplication. The long distance geminates are multiple correspondents of one input segment (see Gafos 1995, and Rose 1997 for similar proposals). There is good evidence that long distance geminates are reduplicants. For example in Chaha (McCarthy 1986) labialization and palatalization processes overapply to long distance geminates.

In (326) we see that Chaha has two morphological categories that are marked by changes on a root consonant.

(326) a. *Labialization*

Personal	*Impersonal*	
dänäg	dänäg^w	'hit'
näkäs	näk^{w}äs	'bite'
mäsär	m^{w}äsär	'seem'

b. *Palatalization*

Imperative

2nd m. sg.	*2nd f. sg.*	
g^{y}äk^{y}ət	g^{y}äk^{y}ət^y	'accompany'
nəmäd	nəmäd^y	'love'
nəqət	nəqət^y	'kick'

The impersonal (326a) is formed by labializing the rightmost available consonant. Only velar and labial consonants can be labialized in Chaha. The 2nd person, feminine singular of the imperative (326b) is formed by palatalizing the final consonant of the root. In both cases, the featural change only affects one consonant.

If the root ends in a long distance geminate, then labialization and palatalization apply to both segments of the long distance geminate.

(327) a.

Personal	*Impersonal*	
säkäk	säk^{w}äk^w	'plant in the ground'
gämäm	gäm^{w}äm^w	'chip the rim'

b.

Masculine	*Feminine*	
bätət	bät^{y}ət^y	'be wide'
səkək	sək^{y}ək^y	'plant in the ground'

If we assume that the long distance geminates are in a base-reduplicant relationship, then the overapplication follows as a base-reduplicant identity effect.

Treating long distance geminates as reduplicants also helps with the lexical OCP problem above. If the inputs /sm/ and /smm/ both surface with a base-reduplicant structure in the output, then they will truly neutralize. The problem is enforcing the base-reduplicant structure. More research on the nature of templatic morphology and long distance geminates is required.

5.1.2 Antigemination - the Surface OCP

In this dissertation I have avoided using a ranked and violable OCP constraint. The Lexical OCP effects discussed here have been derived from very general markedness considerations. However, there are some OCP effects that occur non-locally, that seem to require an OCP constraint. For example the Arabic root cooccurence restrictions, or dissimilations (Alderete 1996, Itô & Mester 1998). Solutions to these problems proposed in OT are not incompatible with the approach taken in this dissertation. However, in this section I want to examine one phenomenon that appears to be problematic, antigemination.

Antigemination (McCarthy 1986) is the blocking of vowel deletion when the vowel subject to deletion is flanked by two identical consonants. It appears that coalescence of identical segments does violate some constraint, thus accounting for the blocking. I will argue that it is only when coalescence is non-local that it is marked.

In Afar (Bliese 1981, McCarthy 1986) an unstressed vowel deletes in the medial of three open syllables.

(328) *Syncope*

xamila	xaml-i	'swampgrass (acc./nom.-gen.)'
ʔagara	ʔagr-i	'scabies'
daragu	darg-i	'watered milk'
digib-t-e	digb-e	'she/I married'
wager-n-e	wagr-e	'we/he reconciled'
meʔer-ta	meʔr-a	'you/he kills a calf'

The examples in (328) show the syncope process in Afar.

Syncope is blocked when the flanking consonants, C_i and C_j, are identical.

(329) *Antigemination*

midadi	*middi	'fruit'
sababa	*sabba	'reason'

xarar-e	*xarr-e	'he burned'
ʔalal-eel-ni	*ʔall-eel-ni	'they competed'
gonan-a	*gonn-a	'he searched for'
adad-e	*add-e	'I/he was trembled'
danan-e	*dann-e	'I/he was hurt'
modod-e	*modd-e	'I/he collected animals to bring home'

In Afar, syncope cannot create a geminate despite the fact that the language has geminates. McCarthy (1986) refers to this blocking affect as anti-gemination and attributes it to the OCP. Antigemination is problematic given the proposal put forth here that there are no constraints against coalescence of like segments. It appears that to account for antigemination we must appeal to a constraint specifically banning coalescence of like segments.

Antigemination in Afar is problematic for correspondence theory since the segments surrounding the targeted vowel are long distance geminates. As discussed above, these long distance geminates are really fissioned single segments. Therefore, under correspondence theory it is surprising that coalescence of these two segments is blocked.

The solution that I propose is that it is not faithfulness to the geminate that blocks merger, but faithfulness to the vowel. I propose that vowel syncope is not complete deletion of the vowel. Rather it is merger of the vowel with the release of the preceding consonant as in (330).

(330) *Syncope as merger with release*

$$\text{dar}_1\text{a}_2\text{g}_3\text{+i} \quad \mapsto \quad .\text{dar}_1{}^{\text{Rel}}{}_2.\text{g}_3\text{i}.$$

When the two consonants are not identical, the first consonant is released onto the second. The vowel gets reduced into this release node. However, when the two consonants surrounding the vowel are identical, then we expect complete coalescence as in Chapter two. Complete merger leads either to loss of the vowel or metathesis between the vowel and the second consonant.

(331) *Syncope blocked between same Cs*

mid$_1$a$_2$d$_3$-i ↦ .mi.d$_{1,3}$i. *MAXV

mid$_1$a$_2$d$_3$-i ↦ .mi.d$_{1,3}{}^{Rel}{}_2$i. *CONTIGUITY

Therefore, *MAXV and *CONTIGUITY are available to rule out vowel deletion in these environments. Furthermore, a pair geminate is ruled out by a Syllable Contact law (Hooper 1976, Murray & Venneman 1983, Clements 1990).

(332) *Syllable Contact Law* Beckman (1997)

SYLLCONT In a sequence VC$_1$.C$_2$V, the sonority value of C$_1$ > the sonority value of C$_2$.

Since the pair geminate does not fall in sonority across the syllable boundary, such candidates violate the constraint SYLLCONT.

(333) *Syncope blocked between same Cs*

mid$_1$a$_2$d$_3$-i ↦ .mid$_1{}^{Rel}$.$_2$d$_3$i. *SYLLCONT

The markedness of coalescence in anti-gemination cases arises because the coalescence is not local, it occurs across a vowel. Local coalescence of pair geminates is still unmarked.

I propose the following ranking for Afar.

(334) *Ranking*

MAXV, CONTIGUITY, SYLLCONT » SYNCOPE » IDENTVFEAT

With the SYNCOPE constraint dominating IDENTVFEAT, vowels can coalesce with the release node of the preceding consonant. The tableau in (335) shows this result.

(335) *Syncope*

/dar$_1$a$_2$g$_3$+i/	MAXV	CONT	SYLLCONT	SYNCOPE	IDENTVFEAT
a. ☞ .dar$_1{}^{Rel}{}_2$.g$_3$i.					*
b. .da.r$_1$a$_2$.d$_3$i.				*!	
c. .dar$_1$.g$_3$i.	*!				

Deletion of the vowel, candidate (c), is blocked by the high ranking MAXV. Since SYNCOPE dominates IDENTVFEAT, coalescence onto the release of the preceding consonant, candidate (a), is possible. However, with long distance geminates, SYNCOPE is forced to be violated.

(336) *Syncope blocked*

/mid$_1$a$_2$d$_3$-i/	MAXV	CONT	SYLL CONT	SYNCOPE	IDENTVFEAT
a. ☞ .mi.d$_1$a$_2$.d$_3$i.				*	
b. .mi.d$_{1,3}$i.	*!				
c. .mi.d$_{1,3}{}^{Rel}{}_2$i.		*!			*
d. .mid$_1{}^{Rel}$.$_2$d$_3$i.			*!		*

Reduction of the vowel, candidate (d), violates the SYLLCONT constraint since the two identical segments straddle the syllable boundary. Complete coalescence of the two segments is ruled out since it either deletes the vowel, candidate (b), or metathesizes the vowel, candidate (c). Therefore the only remaining possibility is to violate the SYNCOPE constraint.

Antigemination appears to be a case where we need to prevent coalescence of like segments. The analysis I present however, shows that antigemination can be the result of faithfulness to the segment that intervenes between the long distance geminate.

5.2 Conclusion

In this dissertation I have argued that the behavior of a geminate segment with respect to some phonological change, whether the result is inalterability, alterability or fission, is decided by two factors. The first factor is the nature of the representation of geminate segments. I have argued here for the Moraic Theory of geminates. The second factor is the nature of the constraints in CON. In this dissertation I have argued for a specific set of universal Faithfulness and Markedness constraints.

I proposed that the single melody theory of geminates can be derived in Optimality Theory by forcing pair geminate inputs to neutralize with singleton segments. This move requires strong restrictions on the types of constraints in UG. The Faithfulness constraints must be unable to distinguish identical adjacent segments from one segment. Therefore, many Faithfulness constraints must be abandoned or reformulated. In addition the markedness constraints cannot prefer pair geminates to singletons. Some Markedness constraints are not possible members of CON in this view.

Geminate alterability occurs when a Markedness constraint actively marks the faithful output of the geminate. Given this situation, geminates must change. Whether the change is total alterability or geminate fission depends on the relative ranking of the Faithfulness constraints and their interaction with the markedness constraints. Fission is driven by onset Faithfulness. Therefore geminate fission provides evidence that onset Faithfulness constraints are in the universal constraint set. In addition, the theory predicts that processes that necessarily change singletons in onsets will never fission geminates.

Universal geminate inalterability requires specific formulation of the Markedness constraints. In order for faithful geminate candidates to be immune from a Markedness constraint, they must do better on that constraint than any other candidate. I have shown some examples of this type of Markedness constraint, NOSHORTCLOSURE, NOSHORTVOICE and the coda restricting *PLACE.

Geminate inalterability can also occur when the result of changing the geminate is more marked than the faithful geminate. This type of geminate inalterability is necessarily local to a specific language, since constraint reranking will lead to languages with altered geminates.

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