The Theory and Typology of Phonological Reordering

by

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DEDICATION

For my grandmothers, Margrith and Jo.

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ABSTRACT

In this thesis, I compare phonological patterns that are fully general across a language (which apply predictably based on sound, without exception) to phonological patterns that bear morphological restrictions. I find that language-general and morphologically-restricted phonology are distinct. The main property I focus on is *Order Preservation*. While complete reordering of segments is possible in morphologically-restricted patterns (such as infixation and reduplication), I argue that language-general phonology is different. Language-general phonology is *Order Preserving*: it never fully transposes or reorders sounds. I demonstrate that putative counterexamples are better analyzed as general patterns of gestural lengthening and overlap, where sounds remain partially anchored in their original positions.

The empirical focus of the thesis is on three phenomena: metathesis, copy epenthesis, and consonant epenthesis. Through in-depth typological surveys, I uncover persistent asymmetries between language-general and morphologically-restricted versions of these patterns. I propose Lamination Theory, a model of phonology that uses separate representational layers for language-general vs. morphologically-restricted phonology. The typological differences between these two kinds of phonology can thus be traced back to their different representations (following Hall 2003). By contrast, theories that assume representational homogeneity (e.g. Cophonology Theory, indexation theory, and Lexical Phonology) cannot derive these asymmetries.

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Chapter 1

Introduction

When we think of phonological patterns, we tend to think of phonology that is *language-general*. Whenever a sequence of sounds occurs, the pattern applies. German obstruent devoicing is one example of such a general pattern. In word-final positions, voiced obstruents become voiceless:

(1) German: word-final obstruents devoice (Brockhaus 1995: 11-12)

a.	/rad/	→ raːt	'wheel'	raːd-ə
	/klaɪd/	→ klaɪt	'dress'	klaɪd-ɐ
	/halb/	→ halp	'half'	halb-ə
b.	/tsaɪt/	→ tsaɪt	'time'	tsaɪt-ən
	/rat/	→ rat	'piece of advice'	ret-ə

However, not all phonology is so general. Other phonology may be *morphologically restricted*: in order to describe where and when the pattern applies, it is necessary to make reference to particular lexical items or morphological classes, not just the presence of sounds and boundaries. Turkish devoicing is an example of a morphologically-restricted pattern. Word-final obstruents devoice, as in (2a.-b.), but only for certain roots. Other roots do not devoice at all (2c.), and this must be memorized based on morpheme identity.

(2) Turkish: final obstruents devoice, with exceptions (Becker et al. 2012)

a.	/tad/	→ tat^{h}	'taste'	cf. tad-ɨ

	/reng/	→ renk^{h}	'color'	reng-ɨ
b.	/saat/	→ saat	'clock/hour'	saat-ɨ
c.	/ad/	→ ad	'name' (*at^{h})	ad-ɨ

When it comes to voicing alternations, the German pattern is more common. Other languages with language-general devoicing include Catalan (Dinnsen and Charles-Luce, 1984), Dutch (Warner et al., 2004), German (Port and O'Dell, 1985), Lithuanian (Campos-Astorkiza, 2008), Polish (Slowiaczek and Dinnsen, 1985), and Russian (Dmitrieva et al., 2010). In comparison, patterns like Turkish are rare.

The puzzle here is that not all phonological patterns share the same bias towards generality. Other phonological patterns have the *opposite* tendency, where morphologically-restricted types are more common. Metathesis, a sound pattern that reorders two sounds, is one such example. Language-general metathesis is attested, but incredibly rare (Blevins and Garrett, 1998; Canfield, 2016; Hume, 1998, 2001; McCarthy, 1995; Ultan, 1971, a.o.). One example here comes from Nivaĉle, where reordering occurs to avoid complex codas (3a.-b.) and rises in sonority across syllable boundaries (3c.-e.).

(3) Nivaĉle metathesis VC → CV (Gutiérrez, 2020, : 293)

a.	/finax-s/	→ finxa-s	'crab-PL'	cf. finax 'crab'
b.	/paset-s/	→ paste-s	'lip-PL'	paset 'lip'
c.	/fin-ɑk-nax/	→ fin-kɑ-nax	'smoker'	fin-ɑk 'tobacco'
d.	/ji-kɑjiʃ-nuk/	→ ji-kɑjʃi-nuk	'my necklace'	ji-kɑjiʃ 'my neck'
e.	/namat͡ʃ-waʃ/	→ namt͡ʃa-waʃ	'axe-mark'	namat͡ʃ 'axe'

Morphologically-restricted metathesis, by comparison, is far more common. For instance, in Georgian a /vr/ sequence metathesizes to /rv/ in the infinitival (4), but this pattern is not fully general. Metathesis does not apply to roots that exceptionally block vowel syncope (5a.), nor to roots that begin with a labial consonant (5b.-c.).

(4) Georgian metathesis with infinitival -v (Butskhrikidze, 2002)

a. /k'ar-v-a/ → k'vr-a 'to bind (inf)'

b. /xar-v-a/ → xvr-a 'to gnaw (inf)'

c. /sxal-v-a/ → sxvl-a 'to chop off (inf)'

d. /jer-v-a/ → jvr-a 'to move (inf)'

(5) But not all words metathesize (Butskhrikidze 2002: 94, 187)

a. /k'er-v-a/ → k'erv-a 'to sew (inf)' *k'vra (cf. 4a.)

b. /ber-v-a/ → ber-v-a 'blow up (inf)' *bvra

c. /da-par-v-a/ → da-par-v-a 'to hide (inf)' *da-pvra

Metathesis, in contrast to devoicing, thus tends to be *morphologically-restricted*.[1] While devoicing patterns tend to generalize and stay that way, metathesis patterns are often restricted to a particular corner of a language's phonology. The core generalization is thus that some phonology, particularly patterns that involve reordering, tend to only occur in morphologically-restricted domains. I call this the Reordering Asymmetry, as in (6):

(6) **THE REORDERING ASYMMETRY**: Patterns that appear to change precedence relations tend to be morphologically restricted.

Conversely, it is often *impossible* to describe reordering patterns by referencing boundaries (e.g. word, morpheme, phrase, etc.) and sound alone.

No theory yet explains the Reordering Asymmetry. In most contemporary phonology, the assumption is that morphologically-restricted phonology and language-general phonology do not differ in any substantive way. Morphologically-restricted patterns are simply those that have been restricted in their domain of application, such as through diacritics (Chomsky and Halle, 1968), cophonologies (Anttila, 2002; Inkelas and Zoll, 2007; Orgun, 1996), phonological strata (Bermúdez-Otero, 1999, 2003; Kiparsky, 2000), or constraint indexation (Pater, 2000; Prince and Smolensky, 1993). But if this view of general vs. restricted patterns is right, we would not expect

[1] See the typological survey in Chapter 3 for more details.

asymmetries such as those between voicing and metathesis rules. The phonological nature of the alternation should not be correlated with how general it is in the lexicon.

The aim of this thesis is to explain why the Reordering Asymmetry exists in synchronic terms. In this, I take a conservative approach: morphologically-restricted phonology must differ from general phonology not just in where it applies, but also its fundamental representations.

In the remainder of this introduction, I outline the gist of the proposal in Section 1.1. Section 1.2 compares the proposal to other bipartite models of phonology. Section 1.3 outlines the rest of the thesis, and Section 1.4 concludes.

1.1 Proposal

In this thesis, I claim that language-general phonology and morphologically-restricted phonology are distinct. Morphologically-restricted phonology contains some mechanisms that are absent from language-general phonology: segmental transposition and copying. Language-general phonology, by contrast, is *order preserving*:

(7) **ORDER PRESERVATION:** Language-general phonology is always *order-preserving*, meaning that it cannot reorder segments.

The kinds of reordering prohibited by Order Preservation comprise more than just metathesis. Infixation, reduplication, and copy epenthesis can also be considered as forms of segmental reordering:

(8) Transposition and non-adjacent copying do not preserve segmental order

a. Metathesis	$/C_1C_2/$	$\rightarrow C_2C_1$	$C_1 \not\prec C_2$
b. Infixation	$/C_1\text{-}C_2V/$	$\rightarrow C_2C_1V$	$C_1 \not\prec C_2$
c. Reduplication	$/C_1VC_2V/$	$\rightarrow \underline{C_1V_2\text{-}C_1}VCV$	$\exists\, C_1 \not\prec V_2$
d. Copy-epenthesis	$/CV_1C_2\text{-}C/$	$\rightarrow CV_1\underline{C_2V_1}\text{-}C/$	$\exists\, V_1 \not\prec C_2$

I assume that Order Preservation follows from the assumption that phonological grammars do not operate over a single, uniform set of representations. Morphologically-restricted phonology uses segments, but language-general phonology uses representations that represent gestural timing.

1.1.1 Two kinds of representations: Segments and gestures

Hall (2003) argues that phonological patterns can be separated by the kind of representations they access: segments or gestures. Segments are atomic, totally ordered, countable units. Gestures, by contrast, are temporal units that represent articulatory movements. They bear inherent duration and timing relationships, but unlike segments, may overlap in time with other sounds. While gestures are a concept borrowed from Articulatory Phonology (Browman and Goldstein, 1990; Browman et al., 1990; Browman and Goldstein, 1986), the usage of both gestures and segments is owed to Hall (2003) and Zsiga (1997, 1993). Both of these theories are distinct from Articulatory Phonology, which assumes that gestures are the *only* kind of phonological representation needed.

Segments and gestures can be distinguished along three major dimensions: phonetic implementation, visibility to other phonology, and sonority-based asymmetries. In this thesis, I demonstrate that when reordering patterns are most general, the following properties apply:

(9) Properties of (gesture-based) language-general reordering (following Hall 2003, 2006)

a. Phonetic gradience/incompleteness, and sensitivity to speech rate

b. Invisibility to stress, word minimality, reduplication, and allomorphy

c. Overlapped / overlapping gestures are almost always sonorants

These properties have been independently argued to be characteristic of gestural timing (phonetic incompleteness: Hall 2003; Zsiga 1997, 1993; invisibility & sonority: Hall 2003), as opposed to segments. I claim that all language-general reordering patterns use gestures to the exclusion of segments.

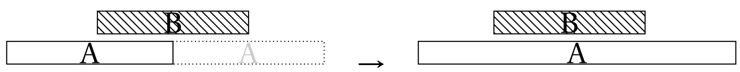
By contrast, morphologically-restricted reordering patterns have behavior consistent with *segmental* representations. They produce phonetically categorical outputs, they may be visible to other phonology, and there is no bias in the quality of the sounds involved. Phonology is thus split into two kinds of representations, segments and gestures, which differ in how they may interact with phonological grammar.

1.1.2 Order Preservation and Gestures

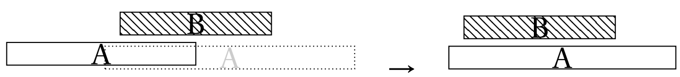
How does Order Preservation play out with gestural representations? While gestural timing may be modified by general phonotactics, there are strict limits. Gestures cannot be fully reordered, which I interpret to mean that one edge of the gestural interval — either the onsets or offsets — must remain anchored in place. Metathesis and copy-epenthesis can thus be understood as gestural overlap, where gestures are stretched across intervening ones to produce *nested* gestures as in (10) below:

(10)

a. Copy epenthesis as gestural nesting: /AB/ → ABA



b. Metathesis as gestural nesting: /AB/ → BA



In these cases, a sound has been displaced, but the final result is not two segments swapping places, nor one segment in two places at once. Instead, a single gesture has been stretched across the intervening one. An aspect of the underlying order is still preserved in the gestural output: The onset of A still precedes the onset of B — further shift of the onset rightwards is prohibited by Order Preservation. The only difference between metathesis and copy-epenthesis is how much of the original gesture 'peeks out' at either end.

In Chapter 3, I demonstrate that existing phonetic data on metathesis supports this analysis. When these patterns are general, we can often observe that the sounds do not behave as if they have fully reordered. Specifically, all language general metathesis patterns in the dataset are phonetically incomplete and phonologically invisible. The displaced sound in language-general metathesis thus behaves as if it remains in its original position.

Before continuing on to the outline of the thesis, I now take a moment to step back and consider the broader implications of Order Preservation for the architecture of grammar. I argue that there are two kinds of phonology: One kind that speakers apply over sound (and boundaries) alone, and another that speakers apply over morphologically-restricted domains. This outcome runs counter to most contemporary phonological theories, which assume that phonology is a single, computationally uniform module of grammar.

1.2 Separationism vs. Phonological Uniformity

While Order Preservation is new, the idea that phonology is separated into two components is an old one, dating back to the Structuralists. The Structuralists had a distinction between "morphophonemic" and "phonemic" rules (e.g. Chao, 1934; Harris, 1942; Hockett, 1942; Swadesh and Voegelin, 1939). Exactly what they mean by "morphophonemic" is often unclear, and varies heavily from writer to writer.[2] At minimum, phonemic rules are those that can be stated only in terms of sound, whereas morphophonemic ones require additional information.

Similar kinds of distinctions survived well into the early generative period: morpheme structure rules vs. phonological rules (Halle, 1959; Stanley, 1967), and morpholexical vs. morphophonemic rules (Matthews 1972, Sommerstein 1975). Parallel distinctions were imported into Lexical Phonology in the lexical vs. postlexical distinction (Kiparsky, 1982; Mohanan, 1982, et seq.), and later yet, into A-Morphous Morphology in the distinction between morphology and phonology.[3] Most recently, this debate has been cast as the distinction between phonetics and phonology (e.g. Cohn 1990; Pierrehumbert 1990, see Section 2.4.4; see also Substance-Free Phonology, Hale and Reiss 2008, et seq.). In each theory, different properties were ascribed to these separate classes of rules: their generality, their timing, their relationship to inputs (e.g. Structure Preservation), or their phonetic naturalness. The names for these internal distinctions within phonological grammar also differ — they can be called morphology and phonology,

[2] A fact which Joos (1958: 92) amusingly bemoaned in his editorial commentary on the papers above.

[3] The distinction between morphemic planes versus phonological tiers (as in McCarthy 1982, et seq.) could also be considered a non-uniform theory, since locality is defined differently between the two (see the Strong Morphemic Plane Hypothesis, Hume 1991; Steriade 1986).

or phonology and phonetics. The core principle, however, remains the same: Phonological grammar is internally divided into at least two components. I call this position **Separationism**.

For the Reordering Asymmetry, these Separationist phonological models offer a clear explanation: the reason why these patterns occur more frequently in morphologically-related forms is due to this division within phonological grammar. Reduplication, infixation, copy-epenthesis, and metathesis are all derived by one component (or at least partially so), but obstruent devoicing is derived by another.

However, not all theories assume a split phonological component of grammar. The more common assumption since the Sound Pattern of English is **Phonological Uniformity**: the idea that there is just one kind of phonology (Chomsky and Halle 1968, though see also Halle 1959: 23-24). Chomsky & Halle explicitly reject the Structuralist division between morphophonemic and phonological rules and representations:

> The term "morpho-phonemic representation" seems to us appropriate only if there is another linguistically significant level of representation, intermediate in "abstractness" between lexical (phonological) and phonetic...We feel, however, that the existence of such a level has not been demonstrated and that there are strong reasons to doubt its existence. (Chomsky & Halle 1968: 11)

Under their proposal, there is no substantive difference between rules that are general and those that apply only to certain morphemes. The restricted rules are ordinary phonological rules that have a diacritic that determines when they apply (Chomsky & Halle 1968: 373). Aside from the diacritic, morpho-phonological rules and phonological rules are identical.

Phonological Uniformity has been the standard in rule-based and constraint-based theories since the SPE (apart from the cases already discussed above, like Lexical Phonology and Substance-Free Phonology). In all varieties of Optimality Theory, for instance, the central hypothesis is that all phonology and morphology are driven by ranking of constraints; derivations do not differ in terms of the operations they use.

> Under Optimality Theory, the universally fixed function Gen supplies all structures; there are no special structure-building or structure-mutating processes that recapitulate the capacities of Gen in special circumstances. Because of Gen, the correct

> form is somewhere out there in the universe of candidate analyses; the constraint hierarchy exists to identify it. In a nutshell: all constraint theories, in syntax as well as phonology, seek to eliminate the *Structural Description* term of rules; Optimality Theory also eliminates the *Structural Change*. (Prince & Smolensky 1993: 223)

These ideas have proven influential, and much work exists focusing on using OT to derive facts previously thought of as morphological (Alderete, 2001; Horwood, 2004; McCarthy, 1995; Wolf, 2008, a.o.) or phonetic (Davidson, 2003; Hall, 2003; Kirchner, 1997; Zsiga, 1997, 1993, to name a few).[4]

Serial OT theories, like Stratal OT (Bermúdez-Otero, 1999, 2003; Kiparsky, 2000) and Cophonology Theory (Anttila, 2002; Inkelas and Zoll, 2007; Orgun, 1996), are no exception here — they also assume Phonological Uniformity. In these OT varieties, the contents of neither GEN nor CON differ from level to level, only the rankings. Any pattern can be morphologically restricted or language-general in principle, since they are all cut from the same cloth.

The Reordering Asymmetry (and by extension, Order Preservation) presents a problem for any theory that adopts Phonological Uniformity. In these theories, morphologically-restricted forms are derived through diacritics or other forms of lexical indexation (as in SPE, Chomsky & Halle 1968: 373-380; or in Parallel OT, Pater 2000, 2009, Gouskova 2012) or serial evaluation of constraint rankings (as in Stratal OT or Cophonology Theory). There is no reason to expect these different kinds of constraint evaluation to derive morphologically restricted patterns differently from language-general ones, and so we are left with a quandary: to revise the assumption that phonology is uniform (either in representation or derivation) or to find an external explanation.

One such alternative explanation is to to turn to learning (cf. Alderete 2008). The idea, under this approach, is that reordering patterns are easier to learn over morphologically-related forms than ones strictly related by sound. While I believe this intuition is on the right track, it also requires scrutinizing exactly what abstract representations speakers use when reasoning about

[4] Of these, Alderete (2001)'s ANTIFAITHFULNESS deserves special mention. In this theory, morphological alternations are derived as a kind of paradigm *anti*-uniformity effect: inputs change so that they can be distinguished from other words in the same paradigm. The interesting thing in ANTIFAITHFULESS is the constraints, which are the exact same faithfulness constraints that constrain ordinary input-output mappings, but reformulated to apply to output-output mappings. Morphologically-conditioned phonology is not only derived in the same grammar, but involve the same core notions of faithfulness.

precedence. Are underlying representations strictly ordered? Are there tiers, or certain kinds of underspecification in precedence that are less consciously targeted? Why should reordering be easier to learn over certain kinds of data than others?

The final answer, I believe, cannot escape from questions of representation. I therefore adopt a fairly conservative approach in this thesis, and attempt to find a way to redefine existing representational tools so capture these two kinds of reasoning about phonological units and order.

1.2.1 Motivations for using Optimality Theory

I cast my proposal in terms of Optimality Theory (Prince and Smolensky, 1993, 2004), and here I briefly explain the reasoning behind this choice. Representational and generative restrictions (as in my theory) are common in other theories, but they are radical in Optimality Theory. Optimality Theory aims to dispense with all constraints on inputs, and reduce phonological typology to a matter of finding the right constraints and rankings (Prince and Smolensky 1993: 223). It's therefore a reasonable question to wonder why I should use Optimality Theory at all, instead of using a framework whose original assumptions are not so firmly against my own.

The problem here is both conceptual and practical. For one, I hope to demonstrate how to construct a non-serial model that does not assume Phonological Uniformity. To date, the only parallel models that exist are those that are in Optimality Theory. It is therefore an important proof-of-concept to show how a bifurcated phonology can be translated into a model of grammar that is evaluated in parallel.

The second, and more practical matter, is that phonologists who do Optimality Theory are often motivated by typology. In this, I share a common goal with these researchers: to explain the typology through detailed case studies on individual languages. However, Optimality Theory (as it now is) poses serious overgeneration issues for the typology of reordering patterns. My aim is to draw attention to this fact, and to argue that we as phonologists must accept that Phonological Uniformity is a problem.

1.3 Outline of the thesis

The theory I propose, Lamination Theory, is laid out in Chapter 2. In a nutshell, the idea is that language-general phonology and morphophonology operate over different representational layers. The timing layer represents general gestural timing relationships, but its control is crude: it can only determine whether sounds are pronounced simultaneously at certain anchor points (or timing slots). The metamorph layer has segmental representations and more detailed information on morpheme identity, and is the layer used for assigning stress, reduplicating, and evaluating other morphologically-sensitive effects.

(11) Representational layers in Lamination Theory

Timing layer:

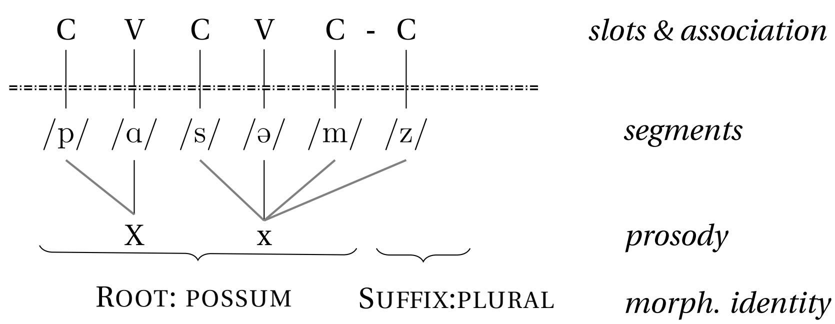
<u>restricted GEN:</u>

spreading, spawn or delete slots, insert features

Metamorph layer:

<u>unrestricted GEN:</u>

can copy, reorder, split, and rewrite



This thesis offers investigations of three main empirical areas. I summarize them here:

Chapter 3. **Metathesis.**

Few languages have metathesis patterns, and fewer still have metathesis that is language-general. The observation is that language-general metathesis patterns bear hallmarks of gestural retiming and overlap rather than complete transposition. Complete reordering, if such patterns do exist, are limited to patterns that are always morphologically-restricted like infixation.

Chapter 4. **Copying.**

This chapter focuses on the typology of copy epenthesis. For consonant epenthesis, I observe that the segments that tend to metathesize — nasals, stridents, glides, laryngeals, and liquids — are the exact same segments that are exceptional in copy epenthesis, both as blockers and transparent segments. I analyze this in terms of spreading.

I also observe that no language has consonant copy epenthesis that targets a non-adjacent consonant (following Kawahara 2007). For instance, there is no language that routinely avoids vowel hiatus by reduplicating the preceding consonant.

(12) *Hypothetical example of the unattested pattern:*

/pata-i/ → [pata-t̲i]	/okor-i/ → [okor-i]
/pata-i-a/ → [pata-t̲i-t̲a]	/okor-i-a/ → [okor-i-r̲a]

I argue that copying, where it occurs (either as the result of morphological reduplication, infixation, or word minimality effects), always have morphological restrictions. I contend that language-general grammar cannot copy segments, but only retime gestures. This accounts for the attested range of vowel copy epenthesis as well as the gap of consonant copy epenthesis.

Chapter 5. **Epenthetic consonant quality.**

In language-general consonant epenthesis patterns, epenthetic consonants have a strong bias to be assimilatory, minimally perturbing the gestural dynamics of the input. For example, no language inserts voiceless stops intervocalically as a fully general epenthesis pattern. Instead, sonorants are preferred in intervocalic positions, and tend to inherit PLACE from surrounding sounds. I propose that segmental insertion mechanisms do not exist in language-general grammar.

1.4 Summary

To review, in this thesis I examine metathesis and copy epenthesis, and argue that when these patterns are fully general, they do not involve complete reordering of segments. Instead, metathesis and copy epenthesis show hallmarks of gestural retiming (in the sense of Hall 2003, 2006). They are phonetically gradient, biased towards sonorants, and are invisible to stress, reduplication, and phonologically-conditioned allomorph selection.

In comparison, when we focus on similar patterns that are morphologically-restricted, we find they have a different typology. The reported phonetic gradience disappears, and they interact freely with stress, reduplication, and allomorphy.

I therefore contend that there is a deep asymmetry in the kinds of alternations found in morphologically-restricted and language-general patterns. This is grounds for rejecting the Phonological Uniformity hypothesis. Instead, I propose that there are two kinds of phonological grammar: a restricted one which can reorder, and a general one which cannot.

This proposal aligns with the intuition that phonology is bifurcated into two components (as in earlier frameworks, see Section 1.2). However, my argument differs from previous accounts in that it focuses on the *character* of the alternations at hand, rather than their interactions such as through derivational ordering. For instance, my proposal does not hinge on any assumption of cyclicity or level ordering between these two kinds of grammar. All derivations can be accomplished either in a parallel or serial model. The core claim I put forth is simply that phonology — cyclic or otherwise — must not be uniform. Morphologically-restricted patterns and language-general ones are computationally distinct, and so any theory that adopts Phonological Uniformity thus comes at a considerable empirical cost. Morphophonology and language-general phonology have different repertoires, and unifying them erases this difference.

Chapter 2

Introducing Lamination Theory

In this chapter, I introduce Lamination Theory, a model of phonology that separates phonological grammar into two layers. Each layer comes with its own set of core operations and representations, but crucially, these layers are not fully separate. Certain kinds of information may pass freely between the layers. Lamination therefore refers to the fact that these layers are distinct, but fuse together to form a single phonological output.

The core premise of Lamination Theory is that phonology is divided into two kinds of patterns: those conditioned only by sound, and those partially conditioned by morpheme identity. The way Lamination Theory accomplishes this is by creating two representational layers in the grammar. There is the timing layer, which has representations for gestural timing and can only reference phonological boundaries and sound. Then there is also the segmental "metamorph" layer, which encodes abstract phonological segments and prosody, and accesses more detailed morphological information. These are schematized in Figure 2.1.

These different representational layers interact with phonological GEN in different ways. In the timing layer, GEN may stretch or compress gestures, but cannot change where they are anchored.[5] In comparison, GEN in the metamorph layer is considerably more powerful. It can fully rewrite and reorder sounds, changing what they are and where they are anchored. In this

[5]Anchored here is just taken to mean where the segment is located in terms of segmental precedence. Segmental position is important for determining how gestural CV diagrams are laminated into gestures in the phonetic output (Section 2.3).

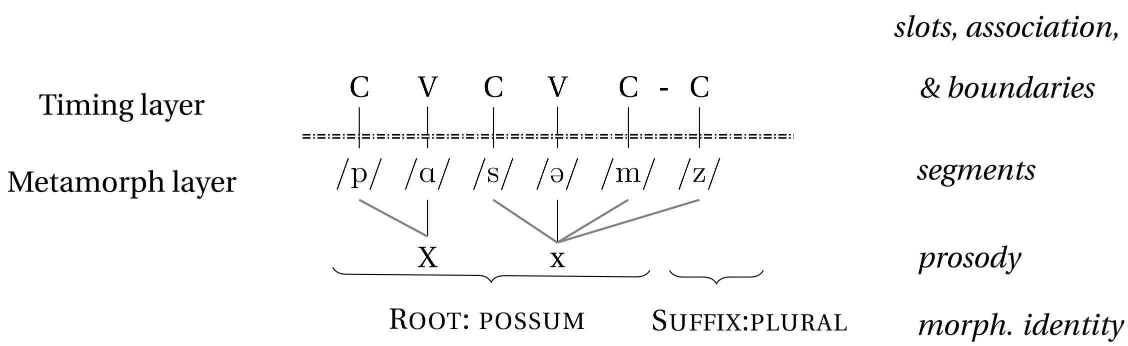


Figure 2.1: Representational layers in Lamination Theory

way, the metamorph layer resembles GEN from standard OT, but the timing layer is far more restricted.

In this chapter, I lay out some of the core assumptions of the Lamination Theory. I start by outlining my representational and architectural assumptions (Section 2.1). Section 2.2 discusses locality assumptions in the timing layer, and how they relate to Order Preservation. Section 2.3 then describes lamination, the process that linearizes the representational layers into gestural scores. Then I discuss how Lamination Theory relates to phonetic gradience (Section 2.4) and phonological invisibility (Section 2.5). Section 2.6 provides a summary of diagnostics, and Section 2.7 concludes.

2.1 The Representational Layers

The central thesis of Lamination Theory is that there are two kinds of phonological representations — those for gestural timing relationships, and those for segments. These representations are manipulated by GEN, the component of grammar responsible for creating candidate sets, in distinct ways.

The general model of grammar I assume is in (2.2) below. Syntax feeds phonology, which has both timing-layer and metamorph-layer components. These layers can be evaluated either serially (metamorph ⇒ timing) or in parallel — the important relationship between them is *invisibility*. I will return to what I mean by invisibility in Section 2.5, but for now it can be

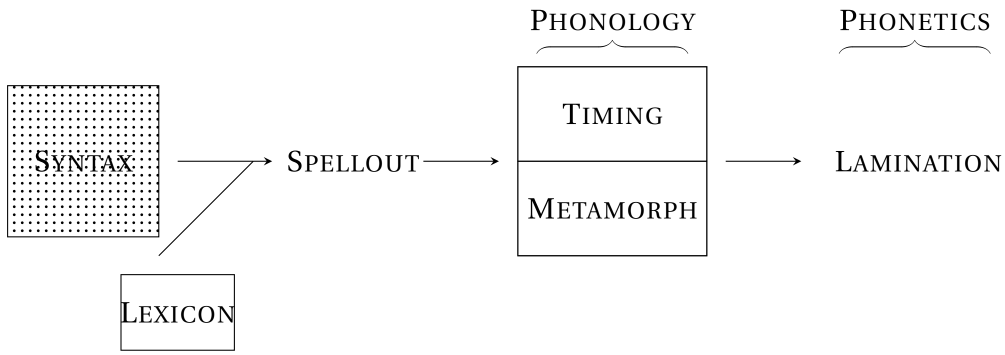


Figure 2.2: The architecture of the grammar in schematic form. Phonology is comprised of two layers, timing and metamorph, which can be evaluated simultaneously or serially. Lamination is the universal process that linearizes bi-dimensional phonological representations into gestural scores.

understood as a kind of restricted interaction between the metamorph and timing layers. The timing layer can reference the outcome of the metamorph layer, but the opposite is not true.

The output of phonology is a two-layered representation composed of segments and timing units, which I will describe in more depth shortly. However, it is important to observe that both of these kinds of representations are abstractions; neither represents actual physical gestures or acoustic productions in the speech stream. These representations must be converted into gestures in a process that I call lamination. Lamination fuses the layers together, transforming the hierarchical representations into gestural ones as best it can.

I now describe each representational layer in detail, starting with the metamorph layer (Section 2.1.1), then proceeding to the timing layer (Section 2.1.2). Section 2.1.3 provides a quick summary. I then proceed to the principles of lamination (phonology-to-phonetics mapping), which will be important for establishing the phonetic predictions of the theory.

2.1.1 The metamorph layer

Metamorph layer representations are, if not the simplest, at least the most congruent with what is assumed in Parallel OT (Prince and Smolensky, 1993), and so I begin with them here. I assume that metamorph layer representations are segmental — phonological units that are arranged in a totally ordered string. Using segments as phonological primitives is challenged in the theory of Articulatory Phonology (Browman and Goldstein, 1990, 1992, 1986). Articulatory Phonology asserts that the only phonological units are gestures, and that segments are at best epiphenomenal — they are not atomic units but rather constellations of gestures that are held in a consistent timing relationship (Byrd 1996:159, Nittrouer et al. 1988, Saltzman and Munhall 1989:365, Löfqvist 1991:346).

However, I follow Clements (1992); Cohn (1990); Hall (2003); Steriade (1990); Zsiga (1993) in arguing that abstract representations are still needed. For many kinds of phonological computation (e.g. reduplication, allomorphy), there are certain kinds of units that are indivisible. Reduplication, for instance, never targets just one gestural articulator to the exclusion of all others in the same constellation (Hall, 2003).[6]

The metamorph layer otherwise behaves much as we would expect under familiar Optimality-Theoretic assumptions. Markedness and faithfulness constraints interact to select optimal outputs. I assume no additional restrictions on what metamorph GEN can do: it can freely rewrite, reorder, insert, and remove segments. Determining any further restrictions, if they exist, is left as a matter for future research.

The critical point of departure from standard Parallel OT is when we examine metamorph CON. Recall, the main claim in this thesis is that of Order Preservation: morphologically restricted patterns may fully reorder segments, but language-general patterns cannot. The metamorph layer, as the component of grammar capable of reordering, must be limited to only apply over morphologically restricted domains.

The question then becomes how to ensure that the metamorph layer's representations are only ever manipulated in morphologically-restricted patterns. One option is simply to say that all metamorph transformations are readjustment rules (Halle et al., 1993): they are stored with particular lexical items or within subdivisions of the lexicon, and so they can only be accessed when these items are present. By the same logic, metamorph transformations could be Cophonologies

[6]The question of whether or not there is additional structure within segments (such as in the form of feature geometries, Clements 1985b; Sagey 1986, et seq.) I consider to be beyond the scope of this thesis. One can adopt feature geometries or simply represent phonological features as a separate matrix — the important thing is that the segment is indivisible as far as phonological computation is concerned.

(Anttila, 2002; Inkelas and Zoll, 2007; Orgun, 1996), kinds of constraint rankings that are stored with particular morphemes. Another option is to use constraint indexation (Gouskova, 2012; Pater, 2000, 2009). Constraint indexation allows constraints to bear a morphological diacritic, so that the constraint is only evaluated when inputs have a matching diacritic. No matter what approach we adopt, the outcome is as desired: there are some kinds of phonology that are only evaluated over subsets of the lexicon.

For the time being, I adopt a constraint indexation approach. The main advantage of constraint indexation is that it allows close comparison with standard Parallel OT: there is just one round of constraint evaluation, and the two layers of phonology only differ in their phonological GEN (framed in terms of representations and Order Preservation). However, I acknowledge that readjustment rules or Cophonologies would also suffice for my purposes here. Readjustment rules differ from constraint indexation in that they do not assume morphophonological alternations are phonologically optimizing. Similarly, Cophonologies differ from constraint indexation by allowing multiple rounds of constraint evaluation. These are empirical questions, and so future work will need to adjudicate more closely on the question of constraint indexation, cophonologies, or readjustment. The core assumption for my argument is simply that the metamorph layer uses segments, and that any metamorph alternations must be conditioned by morphemes.

In summary, the metamorph layer is the layer responsible for all morphologically-restricted phonology, including phenomena like reduplication, infixation, and other forms of long-distance interaction. Unlike the timing layer, the metamorph layer has no requirement of Order Preservation. It can reorder segments, but only in response to the needs of particular morphemes.

2.1.2 The timing layer

The timing layer of phonology determines how segments are mapped into intervals of time. I broadly adopt the notation of Autosegmental Phonology (Goldsmith, 1976), and assume that timing slots represent points of simultaneity, following Sagey (1988); Zsiga (1997). When two segments are associated with a single slot C/V, then there must be some point in time when they are pronounced simultaneously. Note that this does not require the sounds to be entirely synchronous — there only needs to be a single timepoint where they overlap.

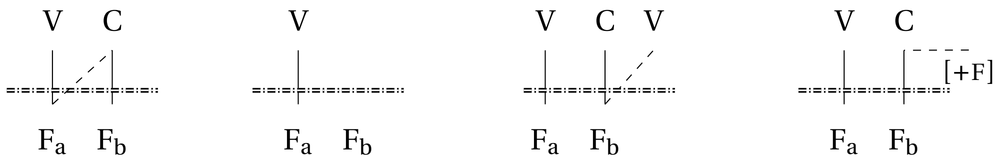
The constraints that reference timing layer representations aim to minimize articulatory duration/effort while also maximizing recoverability. We can understand these two aims as two kinds of markedness constraints: those over sequences of slots, and those over association. When there are fewer timing slots, less time is needed to pronounce an utterance. However, when the association of segments to timing slots is not one-to-one, it is more difficult for speakers to recover what the underlying sequence of segments was. All timing layer alternations can thus be understood as the interaction between slot and association-type markedness, which represents the conflict between articulatory and perceptual pressures.

Concretely, I assume strong restrictions on GEN in the timing layer. The idea here is that GEN can only manipulate the timing or degree of gestures, but it cannot rewrite them fully. Timing GEN can make gestures overlap, it can mutate them, weaken them, or lengthen them. I formalize these as spreading, feature insertion, slot deletion, and slot spawning, shown in (13) below.

Of these, slot spawning and feature insertion deserve specific mention. Slot spawning differs from straightforward slot insertion because it requires an association relation between an existing feature and an epenthetic slot. There is no insertion of bare slots, which will be important in Chapter 5 on consonant epenthesis. Feature insertion may seem out-of-place in the timing layer, but I argue that it is empirically necessary. For instance, some languages avoid word-final voiced obstruents by nasalizing them (e.g. Noon, Section 2.1.2.1). No amount of spreading, slot deletion, or slot spawning can create a nasal feature where there was none before. In essence, the problem here is that sometimes gestures truly are *changed* in general ways, adopting properties that were never in the input. Feature insertion is meant to fill this gap, and will be important in Chapter 5 for deriving the correct typology of epenthetic consonants.

(13) Four core operations of timing Gen:

a. Spreading b. Slot deletion c. Slot spawning d. Feature insertion



These kinds of manipulations create candidates that fall into familiar patterns: assimilation, deletion, coalescence, epenthesis, and so on. Timing Gen creates these candidates, and sends them to Eval, which marks violations for different faithfulness violations like *Multiple, Dep[F][7], *Float, and *Spawn.

(14) Some constraints in the timing layer:

a. *Multiple: 'Slots are associated with just one segment'

For a slot C/V that is associated with a segment x_i, assign a violation for each segment x_j that is also associated with that slot.

b. *Float: 'Don't let segments be unassociated'

Assign a violation for a segment not associated with any slot.

c. Dep[F]: 'No features in the timing layer'

Assign a violation for a feature [±F] that is in the timing layer.

d. *Spawn: 'Segments are associated with only one slot'

For a segment x associated with a slot C_i/V_i, assign a violation for each slot C_j/V_j that is also associated with that segment.

Timing Gen can thus only manipulate the presence of slots and association lines, but it cannot manipulate segments, the location of stress, or any "deeper-level" effects. Later on, this

[7]Dep[F] can be understood as a kind of structure-minimizing constraint, described elsewhere as *Struc (see Gouskova 2003). Gouskova (2003) challenges the existence of *Struc constraints on the grounds that they predict unattested patterns (e.g. unattested inventory gaps, emergence of the marked in reduplication, etc. see Gouskova 2003, Ch 2). However, all of these unattested gaps involve *Struc constraints defined over segments and syllables — all representations of the metamorph layer. I contend that *Struc constraints *are* licit in the timing layer in the form of Dep[F]. Note that this does not generate many of the unattested problems Gouskova (2003) observes — avoiding feature insertion in the timing layer will predict fewer language-general alternations (like devoicing), but will not reduce all structure.

property of timing Gen will help us derive the phonological invisibility of language-general patterns. The reason why language-general phonology is always inert with respect to segments, stress, and allomorphy is because timing Gen cannot manipulate those entities. Instead, timing Gen must work with what it already has, changing association lines and slots but nothing else. Throughout this dissertation, I will visually represent this limitation on timing Gen with a horizontal double dotted line — timing Gen can only manipulate representations above that line.

Timing Con also differs from metamorph Con in that its constraints cannot reference morpheme identity. This stipulation is related to the empirical observation that morpheme-driven effects do not have gradient outcomes (see Section 2.4).

Timing-layer effects, by comparison, cannot reference morpheme identity and so they will be language general. Timing-layer patterns are also expected to be phonetically gradient, since their outputs may change association lines, but not the deeper segmental or prosodic structure. The phonetics will laminate the two layers together, and will thus split the difference when the metamorph and timing-layer representations conflict.

2.1.2.1 Sample derivation: Russian devoicing

An example of a timing-layer derivation comes from Russian devoicing, where voiced obstruents become voiceless in word-final position (*[+Voi,-Son]# in (16) below). A faithful parse for an input like /god/ 'year' in (15) violates *[+Voi,-Son]#. (As I argue in Section 2.4.1, this devoicing must be driven by a requirement to link [-voice] to the last consonant rather than a prohibition on [+voice] in that position: the neutralization between /t/ and /d/ is incomplete.)

Input /god/ 'year' violates *[+Voi,-Son]#

(15)

```
C   V   C
|   |   |
g   o   d
```

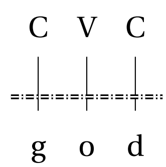
(16) *[+VOI, -SON]#: 'Word-final sounds that are not sonorants must be voiceless.'

When a [-SON] segment is in word-final position and is associated with a C-slot, assign a violation if its associated slot does not also bear a [-VOI] specification.

Timing GEN creates a candidate list as in (17a.-e.). Candidates are created that differ in the presence of a C/V slot, inserted features, or association lines, or some combination thereof.

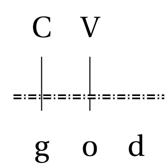
(17) Timing GEN creates candidates a.-e.

a. Faithful candidate



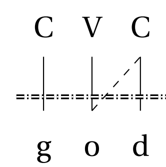
[god]

b. Slot deletion



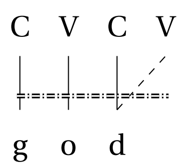
[go] ∼ [go^{d}]

c. Spreading



[god^{w}] ∼ [gow^{d}] ∼ [gol]

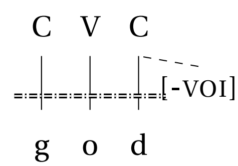
d. V-slot spawning



[godə] ∼ [godɨ]

e. Feature insertion

(the actual winner in Russian)



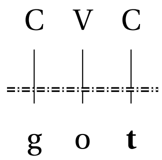
[got] ∼ [god̥]

By contrast, candidates as in (18a.-c.) *cannot* be created, these all require manipulating the metamorph layer.[8]

[8]The "copying" candidate in (18b.) does not address the markedness violation in this word, but it could in others. In a word like /lad/ 'harmony', *[lal] would also resolve the *+VOI,-SON# violation.

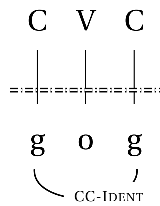
(18) Timing GEN cannot create candidates with other kinds of changes

a. Segmental rewrite



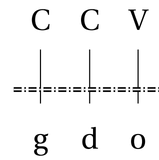
[got]

b. "Copying" by assigning surface correspondences



[gog]

c. Reordering



[gdo]

Russian prefers to insert features (candidate e.) rather than delink (candidate b.), spread (candidate c.) or spawn a vowel (candidate d.).

(19) Sample tableau for Russian devoicing in the timing layer

/god/	*[+VOI,-SON]#	*FLOAT	*MULT	*SPAWN-V	DEP[VOI]
a. C V C / g o d [god]	*!				
b. C V / g o d [go] ∼ [go^{d}]		*!			
c. C V / g o d [god^{w}] ∼ [gol]			*!		
d. C V C V / g o d [godə] ∼ [godɨ]				*!	
☞ e. C V C [-VOI] / g o d [got] ∼ [god̥]					*

The resulting output is a devoiced /d/, bearing [+VOI] (in the metamorph layer) and [-VOI] (in the timing layer). In Section 2.4 I will return to this fact, and connect the contradictory specifications for [VOI] to incomplete neutralization in Russian devoicing. In a nutshell, Russian devoiced stops are distinct from faithful voiced/voiceless stops because they carry both feature specifications.

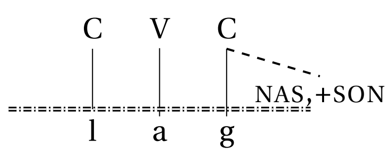
An alternate derivational path here would be to insert sonorant features to prevent the *[-SON, +VOI]# violation. Depending on the exact features inserted, this could produce something like *[gol] or *[gon]. Needless to say, Russian does not do this — it ranks DEP[SON] ≫ DEP[VOI] — but there are other languages that do. In Noon (Cangin), word-final voiced obstruents are nasalized, as shown in (20). (Voiceless obstruents and nasals do not alternate.)

(20) Noon nasalizes word-final voiced obstruents (Soukka 1999: 49)

a. /ab/	am	'hold'	cf.	ab-in	'hold-PFV'
b. /sod/	son	'be tired'		sod-in	'tired-PFV'
c. /paɟ/	paɲ	'marry'		paɟ-in	'marry-PFV'
d. /lag/	laŋ	'shut'		lag-in	'shut-PFV'

We can represent this as feature insertion of [NAS, +SON], as in (21). Note here that the segments (below the dotted line) remain unchanged; the only thing that has happened here is that [NAS] and [+SON] features have been layered on top. I connect this kind of feature insertion to phonetic gradience in Section 2.4. Noon thus ranks DEP[VOI] ≫ DEP[+SON,NAS], the opposite of Russian.

(21) Feature insertion in Noon nasalization: /lag/ → [laŋ] 'shut'



In comparison to other theories, Lamination Theory has less built-in flexibility in how to avoid these *[+VOI,-SON]# sequences. Other theories could model obstruent devoicing as feature obliteration (e.g. [-VOI] → ∅) or feature rewriting (e.g. [+VOI] → [-VOI]). Lamination Theory cannot do this. Timing GEN can only manipulate CV representations "from the neck up" – GEN can create candidates that have different slots, association lines, or non-segmental features, but the segments themselves cannot change. Later on, this inherent brittleness of timing GEN will be important for capturing the restricted typology of epenthetic consonants (Chapter 5), as well as the invisibility of language-general phonology (see Section 2.5).

2.1.3 Interim summary

I summarize the core characteristics of the representational layers in Figure 2.3. The metamorph layer uses segmental representations, and the timing layer uses ones that manipulate gestural timing.

	Metamorph layer	**Timing layer**
Representations:	Segments, prosody, morpheme identity	Slots, association lines, and boundaries
Restrictions on GEN*:*	none	Can only spread, delete/spawn slots, or insert individual features
Order Preservation:	Reordering permitted	No segmental reordering; timing can only be changed via association (e.g. spreading)
Restrictions on CON*:*	Constraints must be indexed to particular morphemes	Cannot reference morpheme identity

Figure 2.3: Core characteristics of the metamorph and timing layers.

A difference between lamination theory and Zsiga (1997) and Hall (2003) is that the phonological representations of both of these layers are abstract phonological units. Neither manipulates gestures directly. The benefit of this is that phonology never has access to fine-grained gestural representations, and as such the degrees of freedom for encoding contrast are tightly restricted.

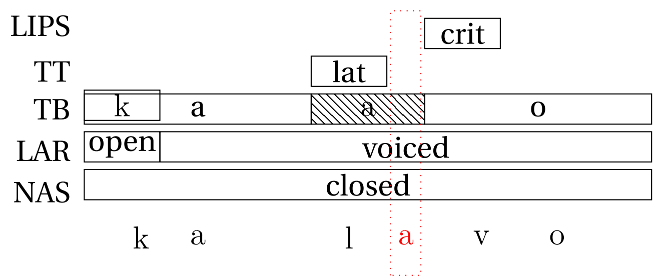
I now proceed to discuss locality restrictions in the timing layer, which distinguish spreading from other forms of reordering. Then, I continue on to lamination, the phonetic process that transforms these representational layers into gestural scores.

2.2 Locality in the timing layer

Timing GEN cannot reorder sounds or copy at a distance — it can only spread. In this section, I briefly discuss the restrictions I assume on spreading in the timing layer.

Hall (2003) argues that intrusive vowels are vowels that fully contain a consonant gesture. For example, in the Finnish word /kalvo/ 'transparency', a intrusive copy-vowel can be heard to produce [kala̱vo] (*ibid.* 16), as shown in (22).

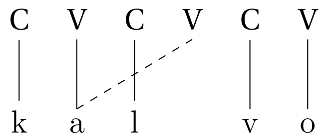
(22) Gestural score of Finnish /kalvo/ → [kala̱vo]



The gestural score here is arranged in terms of five articulators: lips (LIPS), the coronal part of the tongue (TT, for tongue tip), the dorsal part of the tongue (TB, for tongue body), the nasal port (NAS), and the larynx (LAR). The vowels are represented as intervals on the dorsal tier (represented in shorthand as [a] and [o] above), where the tongue body narrows the oral constriction but does not make a full closure. Crucially, the closed coronal gesture for the [l] does not overlap in time with the critical labiodental gesture for the [v]. There is thus a brief period of time where there is no oral constriction other than the dorsal vowel gesture — this is the intrusive vowel.

If we adopt Hall (2003)'s proposal on intrusive vowels, then we need some way to represent the broad gestural phasing in (22) in terms of timing layer representations. In Lamination Theory, timing-layer C and V slots represent simultaneity, and so one way to produce configurations as in (22) is to spread the vowel rightwards to a following slot, shown in (23).

(23) Finnish copy epenthesis as spreading



Vowel spreading of this kind is a standard way to analyze copy-epenthesis (Bugenhagen et al. 1991: 52, Akinlabi 1993, Kawahara 2007), but note here the association lines between the consonant and vowel cross. This is not a notational accident. I assume that association lines may cross in the timing layer.

Despite appearances, allowing line-crossing is not deeply at odds with many spreading-based accounts to vowel harmony (cf. Kimper, 2017, 2011). Avoiding violations of the No Crossing Constraint (Goldsmith, 1976) is a major issue for almost all spreading-based accounts of vowel harmony, requiring elaborate representational moves such as assuming planar segregation of consonants and vowels (McCarthy, 1979, 1981; Steriade, 1986, a.o.), extensive feature geometries (Clements, 1980, 1991; Sagey, 1988), or other ways of limiting the NCC to only apply between legitimate targets (see review in Ní Chiosáin and Padgett, 2001; Odden, 1994). By casting this as line-crossing, I take a direct approach: line-crossing is not the problem, but instead an abstract restriction of like spreading over like.

2.2.1 A placeholder restriction: The Rule of Most Specified

For the purposes of this thesis, I assume a placeholder on locality that I call *The Rule of Most Specified*. This rule is a restriction on timing GEN that prohibits candidates with certain line-crossing configurations.

(24) THE RULE OF MOST SPECIFIED: One association line can only cross over another if its associated segment contains more features than the other.

The Rule of Most Specified is a simple feature-counting mechanism. Line-crossing is only permitted when a more-specified segment crosses over a less-specified segment. When segments contain an identical number of features, their association lines cannot cross.

The empirical coverage offered by this placeholder is similar to what would be obtained by using tiers or feature geometries: like cannot spread over like. For instance, vowels should generally contain a similar number of features to other vowels, and so we expect for vowel-vowel line crossing to be uniformly illicit. Two nasals should also be unable to cross over one another, as should two similar obstruents.

However, *The Rule of Most Specified* also rules out a variety of other spreading configurations, such as where less-specified segments would cross over more-specified ones. Some of these are listed in (25) below. Since these spreading asymmetries are dependent on the system of underspecification and contrast in a language, this list is not necessarily exhaustive nor universal. The nature of such universals, if they exist, is the purview of the robust typological literature on contrast and underspecification (see Archangeli 1988; Clements 1985b; Halle 1995; Sagey 1986, a.o.).

(25) Spreading asymmetries derived by *The Rule of Most Specified*

a. Vowels can spread across consonants, but consonants cannot spread across vowels.
Assumption: vowels contain consonant features, but not vice versa (Clements, 1985a, 1991; Halle, 1995).

b. Nasals can spread across obstruents, but not vice versa.
Assumption: sonorants contain [±] nasal features, but obstruents may be underspecified for nasality (Piggott, 1992; Rosenthall, 1989).

c. Stridents can spread across obstruents, but obstruents cannot spread across stridents.
Assumption: stridency is only specified for coronals (Kim et al., 2015; Ladefoged, 1971; Shaw, 1991), and may be underspecified elsewhere.

d. Sonorants may spread across obstruents, but obstruents may not spread across sonorants.
Assumption: Only sonorants are specified for [+/-NAS], [+/-LAT] (Piggott, 1992; Rice and Avery, 1989; Rice, 1992).

The Rule of Most Specified can also be understood as a placeholder for sonority. If we arrange the assumptions in (25) into the form of a featural matrix, as in (26), we find that more-specified sounds are precisely those that have been argued to be more sonorous (Bell and Hooper, 1978; Clements, 1990; Jespersen, 1904).

Obstruents are the least specified, and so are the least likely to be able to spread. As we go down the chart, we see that nasals, glides, and vowels bear additional features, and we expect for line-crossing of these segments to be permitted in more circumstances, since they will generally bear more features than surrounding sounds.

(26) Natural classes, arranged from least to most specified

	NAS	LAT	STR	ROUND	HIGH	# of addtl. features
obstruents	0	0	0	0	0	0
nasals	+	0	0	0	0	1
liquids	(+/-)	+/-	0	0	0	1 or 2
stridents	0	0	+	0	0	1
labials	0	0	0	+	0	1
glides	(+/-)	0	0	(+/-)	+	1 to 3
vowels	0	0	0	+/-	+/-	often more than 2

In Chapter 3, I return to this connection between sonority and specification. In the typologies of metathesis and copy-epenthesis, sonorants are known to condition and undergo displacement more often than other sounds (Hall, 2003, 2006; Ultan, 1971). One way of understanding the sonorant bias is as a functional pressure, where sonorants need longer for their cues to be realized. Here I place this intuition in more general terms: when contrasts are particularly dense in an inventory (bearing more features), then it is favorable to extend the sound across others. *The Rule of Most Specified* thus offers a way of integrating sonority hierarchies into the model without requiring a separate analytical mechanism.

To sum up, *The Rule of Most Specified* here is intended as a placeholder, and could easily be replaced by assuming tiers, feature geometries, or other analytical tools like sonority. The core purpose of *The Rule of Most Specified* is to ensure two things: (i) that like cannot spread over like, and (ii) that higher-sonority segments are more likely to spread. Exactly how these are encoded is not of central importance to this theory, and so I use a feature-counting mechanism because it is both simple and explicit.

In the next section, I discuss how these two-layered phonological representations are transformed into gestures. While previous work has argued that line-crossing induces fatal linearization conflicts (see Sagey 1986), here I demonstrate that it is not necessarily so: line-crossing produces *nested* gestures, where the gesture for the crossing segment fully contains the sound being crossed over.

2.3 Lamination: Transforming phonology into gestures

In this section, I show how phonological representations (composed of metamorph and timing layers) are fused together into a single phonetic output, which I call *lamination*. Important predecessors to lamination include Gafos (1999); Steriade (1990); Zsiga (1997, 1993), which also explore how Autosegmental representations could be intuitively understood as representations of gestures. However, none of these previous studies made the mapping from bidimensional representations to gestures explicit. The aim of this section is to formalize this link.[9]

Lamination comprises the principles of linearization that are invariant from language to language. I claim that lamination is essentially preservative, where it attempts to maintain the character of the layers as best it can. As such, I argue that lamination has important corollaries for both *Order Preservation* (the prohibition on complete reordering) and *The Rule of Most Specified* (the prohibition of like spreading over like). There are principles of lamination that mimic these properties, and provide crucial cues to language users that a given effect should be analyzed in the timing layer.

The section is structured as follows: Section 2.3.1 begins with some basic assumptions on segments, slots, and association. Section 2.3.2 then turns to how lamination encodes Order

[9] For readers who want a quick overview of these principles, proceed straight to Section 2.3.5.

Preservation and The Rule of Most Specified. Section 2.3.4 then discusses the kinds of information that lamination does *not* encode, such as fine-grained intergestural timing — these are expected to be language-specific parameters that must be learned. A quick summary of the lamination principles is found in Section 2.3.5.

2.3.1 The basics: Segments, slots, and association

In this section, I quickly go through several basic assumptions on how segmental-timing representations are transformed into gestures. I begin with the simplest one, *Segment Realization*. For any segment present in the representation, there must be a gesture that realizes it.

(27) RULE 1. SEGMENT REALIZATION. If a segment is present in the metamorph layer, then there must be some gesture that corresponds to it.

However, this does not mean that the gesture must be fully audible. The resulting gesture may be obscured by neighboring gestures (as in Browman and Goldstein (1990)'s [pɚfɛk mɛm. . .] 'perfect memory'), or it may simply not fully reach its target (see Purse (2019) on English t/d deletion). The expectation is that when we examine articulatory data, that we should see evidence of some movement for any segment present in the phonological representation.

The second rule, *Overlap*, states that when two segments are associated with a single slot, there must be some point where they are pronounced simultaneously (following Sagey 1988). Another way of saying this is that for any two segments associated with a single slot, there must be a transition point where their two gestures are in contact.

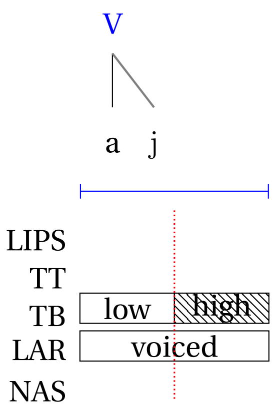
(28) RULE 2. OVERLAP. 'When slots and features are associated, they must overlap in time' Given a slot X that is associated with a non-zero set of segments S_a, S_b, . . . , S_n, then the laminated gestural output must contain gestures G_i, G_j, . . . , G_z corresponding to S_a, S_b, . . . , S_n such that there is a timepoint when G_i, G_j, . . . , G_z are simultaneous.

Like *Segment realization*, this moment of overlap may or may not be audible depending on the other gestures present. The only requirement is that it is produced.

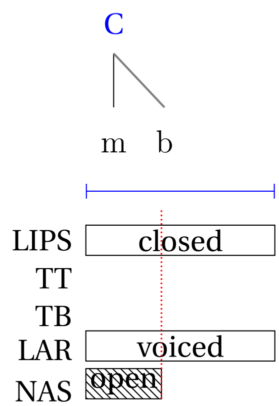
To illustrate, consider multiple-association for a vowel-offglide sequence and prenasalized stops, as in (29). In both of these cases, there is a timepoint where they are realized simultaneously (the transition point), marked with the vertical red line.

(29) Multiple-association indicates overlap (cf. Steriade 1990: 384)

a. Vowel-offglide: Multiple-Association to V



b. Prenasalized Stop: Multiple Association to C

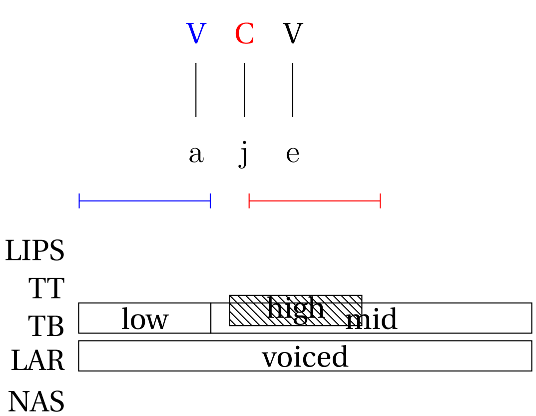


In comparison, forms where features are not associated with the same slot do not automatically require this kind of overlap. Consonant-vowel sequences, as in (30a.), may be separated with no timepoint at which they overlap. Similarly, consonant-consonant sequences have no requirement to meet, and so it should be possible for there to be a clear release or excrescent vowel between the two consonants (30b.).

(30) One-to-one association indicates contiguity, but not overlap

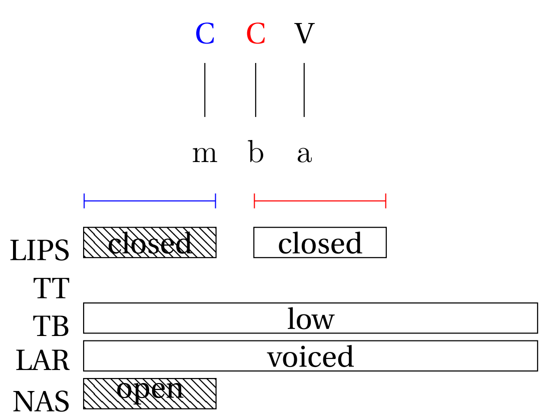
a. Vowel-Consonant sequence:

Two feature bundles, one V, one C



b. Consonant-Consonant sequence:

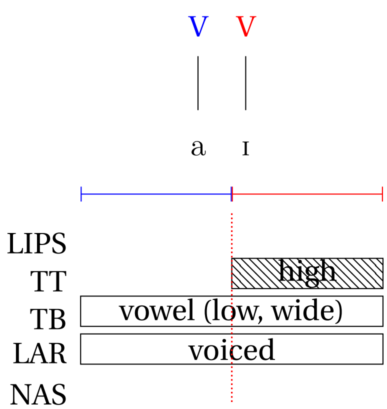
Two feature bundles, two C's



In languages where these transitions must overlap, such as in [mb] clusters, then these two C-slots must be connected by an additional association line. This will again force the two gestures into contact, but is not otherwise required by lamination.

Vowel-vowel sequences, however, are different. I assume that vowel gestures are contiguous, following Browman & Goldstein (1990: 12). As a result, in a vowel hiatus sequence like [a.i], the two vowels must also overlap at some point, as shown in (31) below.

(31) Vowel-vowel sequences must be contiguous:



I therefore posit a third rule, *Vowel slot contiguity*, which requires two adjacent V-slots to be realized as contiguous gestures.

(32) RULE 3. VOWEL SLOT CONTIGUITY. 'When two V-slots have no other V-slots between them, they must be contiguous'
For two V-slots V_i and V_j associated with segments S_a and S_b, where $V_i \prec V_j$ and there is no V_k such that $V_i \prec V_k \prec V_j$, then there must be a point in time where the gestures corresponding to S_a and S_b overlap.

To summarize, here I described three simple rules for lamination. First, when a segment is present, it must have some gesture corresponding to it (Rule 1: Segment Realization). Second, when two or more segments are associated with one slot, they must overlap (Rule 2: Overlap). Third, two V-slots must have contiguous vowel gestures (Rule 3: vowel slot contiguity). I now proceed to how lamination encodes precedence relations.

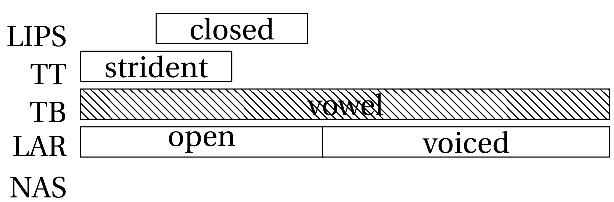
2.3.2 Laminating Order and Line-Crossing

Lamination needs some way of encoding the linear order found in phonological representations. One potential problem here is that phonetic representations are not totally ordered, but phonological representations are. For instance, consonant gestures are often superimposed over continuous vowel gestures (Fowler, 1983; Öhman, 1966). What this means is that the consonant and vowel begin at more or less the same time, even though in the phonological representation, the consonant precedes the vowel in terms of both segments and slots.

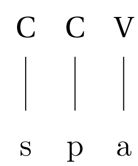
An example of this is shown in (33a.) for the word [spa], which has a single contiguous vowel gestures with the consonants above it. The representation for [spa] is given at right in (33b.).

(33)

a. Vowel gesture with superimposed consonants for [spa]



b. Representation for [spa]



We therefore need a way for a consonant to precede a vowel in the segmental structure, but for their gestures to not strictly follow one another in the output.

I therefore propose Rule 4: The Law of Order Preservation. There are two parallel requirements, one for segments (34) and one for slots (35).

(34) RULE 4: ORDER PRESERVATION (SEGMENTS). 'When a segment precedes another segment in the input, the first must start first, or the last must end last'

When a segment S_a precedes a segment S_b, and S_a corresponds to a gesture G_a and S_b corresponds to a gesture G_b, then:

a. the onset of the G_a must occur before the onset of G_b, **OR**,

b. the offset of G_b must occur after the offset of G_a.

(35) RULE 4: ORDER PRESERVATION (slots): 'When a slot precedes another slot in the input, the gesture of the first must start first, or the gesture of the last must end last'

When a slot X_i precedes X_j where X_i is associated with S_a and X_j associated with S_b, and S_a corresponds to gesture G_a and gesture S_b corresponds to G_b, then:

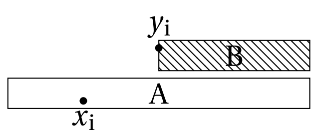
a. the onset of the G_a must occur before the onset of G_b, **OR**

b. the offset of G_b must occur after the offset of G_a.

The Law of Order Preservation requires that when segment A precedes segment B, that A must start first, or B must end last. This is shown in (36) in schematic form.

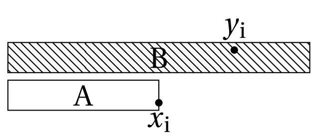
(36) When segment S_a precedes segment S_b...

a. The onset of S_a must precede onset of S_b



$\exists$ x_i of S_a such that $x_i \prec y_i$ for all y_i of S_b

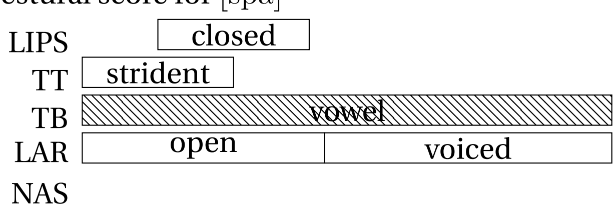
b. The offset of S_b must follow the offset of S_a



$\exists$ y_i of S_b such that $y_i \succ x_i$ for all x_i of S_a

We can now refer back to the gestural score for [spa] from (33) and confirm that Rule 4 is satisfied. I reproduce the gestural diagram in (37) below.

(37) Gestural score for [spa]



There are three precedence relations to check: [s] ≺ [p], [p] ≺ [a], and [s] ≺ [a]. For the first one, we see that the onset of [s] precedes the onset of [p], which reflects that [s] ≺ [p]. The vowel *offset* then follows both the offset of [s] and the offset of [p], reflecting that [a] ≻ [s] and [a] ≻ [p].

In representations that allow line-crossing, we need one further rule for lamination. I call this The Law of Specified Gestures, provided in (38):[10]

(38) RULE 5: THE LAW OF SPECIFIED GESTURES. When one gesture contains another, the gesture of the more specified segment must contain the gesture of the less-specified segment.

The Law of Specified Gestures ensures that when A crosses over B, that the gesture for A can contain B, but not vice versa. In essence, it requires gestural scores to realize the intuition that when A spreads, it should become larger. I walk through this in more detail in Section 2.3.3, where I demonstrate how these five principles of lamination apply to metathesis.

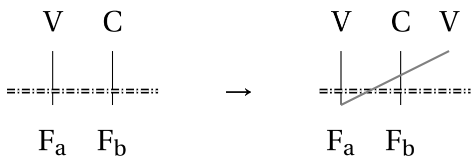
Beyond these two laws (Order Preservation and Specified Gestures), lamination does not make any further requirements for intergestural timing. The precedence it encodes is quite weak, and so there are more gestural scores than the one shown in (37) that should also be possible outputs. I return to these possibilities in Section 2.3.4, and contend that they are outside of what phonology should be designed to account for. Finer intergestural timing is neither universal nor phonologically contrastive, and is thus best left as a language-specific phonetic parameter.

2.3.3 Illustration: Laminating Metathesis

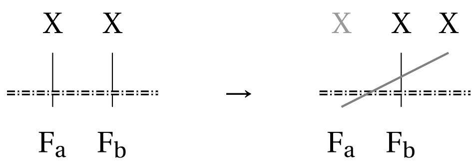
Here I illustrate the principles of lamination on representations that involve line-crossing, namely metathesis. As a preview, the analysis that I propose for metathesis and copy-epenthesis is based on *spreading*. In copy epenthesis, markedness pressures force a segment to spread (39), and in metathesis, a segment spreads and deletes its original slot (40). (In Chapters 3 and 4 I return to these representations in more depth, but for now let us assume that these are the correct ones.)

[10]An alternative here is to state The Law of Specified Gestures in more general terms: when one gesture contains another, it must be more specified than the gesture it contains. This definition would apply well to the typology of prenasalized stops, where [mb] and m͡bm are attested, but [b͡mb] is not (Stanton, 2017). The [b] gesture can never contain [m] because it is less specified.

(39) Copy-epenthesis in the timing layer



(40) Metathesis in the timing layer

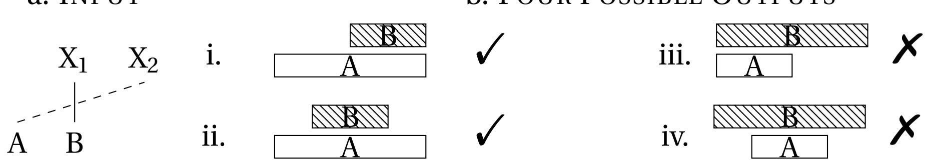


Previous work contends that configurations with line-crossing as in (39) produce intractable problems for linearization. Sagey (1986), for example, observes that in Goldsmith (1976), association lines represent exclusive simultaneity: a segment associated with a slot must be realized exclusively at that point in time. Line-crossing, Sagey claims, should therefore yield a contradiction, since two sounds would need to be pronounced at once. However, in lamination theory, no contradiction is obtained. If we assume that phonetic outputs are gestures, then there is nothing contradictory about two sounds being produced at once.

To illustrate, when we linearize the metathesized representation in (41a.), we first begin by creating gestures for each segment (Rule 1: Segment Realization). Since there is no multiple-association or vowels in (41a.), Rules 2 & 3 (for overlap and vowel slot contiguity) are irrelevant here, and we can proceed to Rule 4: The Law of Order Preservation. The Law of Order Preservation only requires a very weak precedence (first starts first or last ends last), and so any of the four gestural scores in (41(b)i.-iv.) satisfy it:

(41) The Law of Order Preservation (Rule 4) allows four possible outputs

a. Input b. Four Possible Outputs



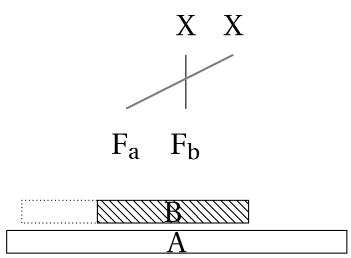
(only i. and ii. satisfy Rule 5: The Law of Specified Gestures)

However, once we consider Rule 5: The Law of Specified Gestures, only (41(b)i.) and (41(b)ii.) are valid outputs. Recall, *The Rule of Most Specified* states that more-specified segments can only cross over less-specified segments (Section 2.2.1). Parallel to this, lamination has a requirement that the *gestures* of segments that cross association lines must contain the gestures of the segments being crossed over. The scores in (41(b)iii.) and (41(b)iv.) are prohibited, because they violate Rule 5 by containing B in A. The output of line-crossing is thus expected to only bear two possible shapes, (41(b)i.) and (41(b)ii.).

Metathesis thus always produces the forms in (41(b)i.) and (41(b)ii.), which I call *nested gestures*. The earliest that B can start is after A. One consequence of lamination is thus that spreading and segmental transposition are expected to have distinct outcomes. In the crossed-line representation in (42a.), some portion of A must precede B. But, when the features are in the opposite order, as in (42b.), A and B may start at the same time.

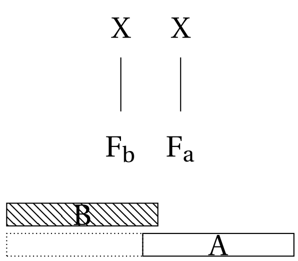
(42) Gestural scores of line-crossing (42a.) and feature reordering are distinct (42b.)

a. Line-crossing generates complete overlap



(the earliest B can start is *after* A)

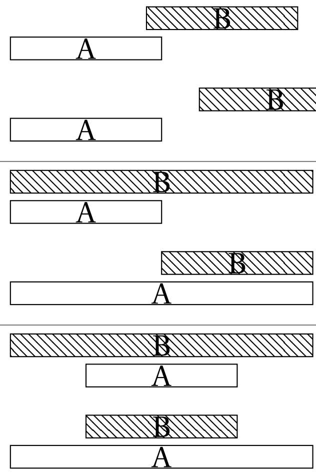
b. When $F_b \prec F_a$, gesture A must start later



(the earliest A can start is *simultaneous* with B)

The fine-grained gestural timing is thus expected to be a critical cue for inferring underlying feature order.

The same information is also provided in Figure 2.4. When segment A precedes segment B,



	Gestural score	Order Pres.?	Lines cross?	Description
a.		✓	✗	Onset of A ≺ Onset of B Offset of A ≺ Offset of B
b.		✓	✗	Onset of A ≺ Onset of B Offset of A ≺ Offset of B
c.		✓	✓ / ✗	Onset of A = Onset B Offset of A ≺ Offset of B
d.		✓	✓ / ✗	Onset of A ≺ Onset of B Offset A = Offset B
e.		✓	✓	*Onset of B ≺ Onset of A Offset of A ≺ Offset of B
f.		✓	✓	Onset of A ≺ Onset of B *Offset of B ≺ Offset of A

Figure 2.4: Possible gestural outputs of the timing layer when $F_A \prec F_B$

lamination can produce any of the forms in (a.-f.). The closest we can get to complete reordering is the forms in (e.-f.), where association lines cross, but either the onset or offset of the gestures still cues the underlying feature order.

While the diagrams in Figure 2.4 (e.-f.) are striking, in Chapter 3 I demonstrate that these nested configurations are widely attested among languages with general metathesis patterns. Andalusian Spanish, for instance, has metathesis that is frequently phonetically incomplete so that the metathesized /h/ fully encloses the intervening stop (e.g. /pestaɲa/ → [pehthaɲa] 'eyelash', Gilbert 2022; Ruch 2008). Similar patterns are also seen in Cayuga (Foster, 1982), De'kwana Carib (Hall, 1988), and Meto (Mooney, 2023). If we widen this further to include epenthesis patterns, then the cases expand further (see vowel intrusion, English: Hall 2003, Finnish: Hall 2003; Karlin 2022). I discuss these patterns in more detail in Chapters 3 (on metathesis) and 4 (on copying). The prediction here is that metathesis should always be phonetically incomplete — an edge of the gesture remains in its original position.

By contrast, the timing layer can never create gestural scores as in Figure 2.5 from an input where segment A ≺ B. No matter how one draws association lines from A and B to slots, either the onsets or offsets must cue the underlying order of features.

To summarize, the laminated phonetic output bears traces of both metamorph and timing

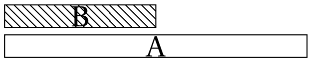
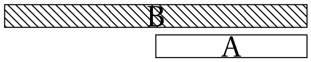
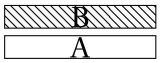
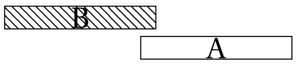
	Gestural score	Order Preserving?	Description
a.		✗	Onset of A = Onset B Offset of B ≺ Offset of A
b.		✗	Onset of B precedes Onset of A Offset of A = Offset B
c.		✗	Onset of A = Onset B Offset of A = Offset B
d.		✗	Onset of B ≺ Onset of A Offset of B ≺ Offset of A

Figure 2.5: Impossible gestural outputs when $F_A \prec F_B$

layer representations. Precedence relations in both layers have an effect on ordering between gestures. When one slot or segment precedes another, then the first one must begin first, or the second one must end last. In this way, the mapping between phonological representations to phonetic gestural scores is also order preserving but weakly so: the relative order of the onsets and offsets allows us to partially reconstruct the representational order.

In the next section, I show how further ordering possibilities (such as those governing intergestural timing) are not determined by phonological representations or lamination. As such, they are not expected to be contrastive, nor are they expected to be universal.

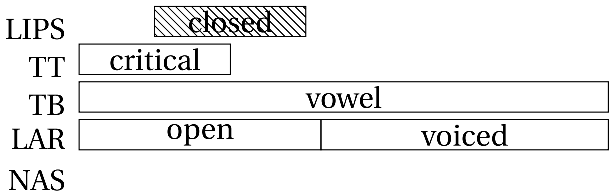
2.3.4 The limit of phonological representations

Lamination transforms representations into gestures, but ultimately, it leaves much open to language-specific parameters in the phonetics. In this section, I briefly discuss some of the things that lamination does not determine, and some consequences this has for phonetic and phonological typology.

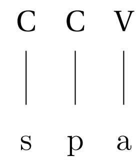
Let's return for a moment to the gestural score of [spa], reproduced in (43).

(43) Gestural score and phonological representation for [spa]

a. Vowel gesture with superimposed consonants for [spa]



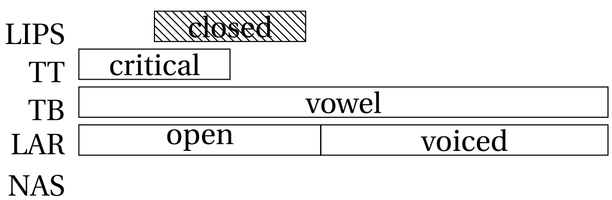
b. Representation of [spa]



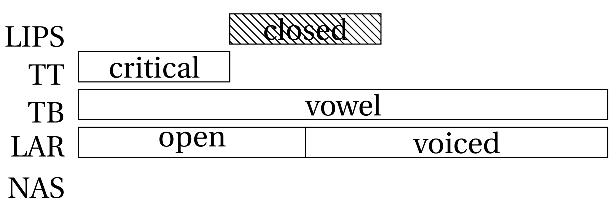
While the score in (43a.) is what we observe in English, lamination can produce other variations as well. For instance, it is possible for the CC transition to be looser, where there is no significant overlap between the [s] and [p], as in (44b.). In clusters where the C_1 is a stop, this would represent an audible release of the first consonant. Another possibility is to have an open CC transition with an excrescent schwa or aspiration, as in (44c.).[11]

(44) Three possible CC transitions from CV representation in (43b.)

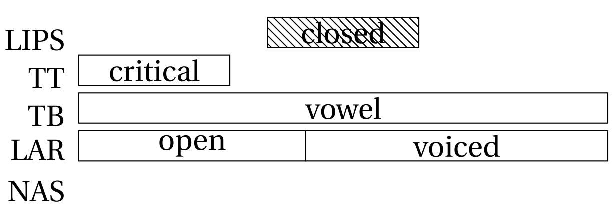
a. Close CC transition with overlap: [s͡pa] (significant overlap, no excrescent vowel)



b. Close CC transition without overlap: [spa] (not much overlap, no excrescent vowel)



c. Open CC transition with excrescent vowel/aspiration: [s^{h}pa]



Each of these gestural scores is consistent with the representation in (43b.) The only thing that

[11]Aspiration ([s^{h}pa]) is shown in (44c.), but it could also be [$s^{ə}$pa] with an earlier start to the voiced LAR gesture.

representation requires is that for each pair of consonantal features, that the [s] onset precedes the [p] onset, or the [s] offset precedes the [p] offset.

I claim that the choice between outputs in (44) is not determined by lamination, but instead set by language-specific parameters. Languages are known to differ on which kinds of CC transitions they prefer. Zsiga (2000), for instance, demonstrates that while English prefers a close transition with overlap (44a.), Russian speakers avoid overlap (44b.). Hall (2003) also observes that the kind of transition is partially determined by speech rate. Native CC clusters tend towards open (44b.) or open-schwa (44c.) transitions at lower speech rates, even though English CC clusters are typically close. The fact that all of these outputs have the same representations and precedence relationships is thus an advantage of my proposal, because it suggests that this variability is not phonologically contrastive.

That said, it remains possible that the choice between outputs in (44) is driven by some module of the grammar — my only claim is that it is not lamination. One problem is that CC transition type is sensitive to an individual language's phonotactics. Davidson (2003) observes that when English speakers produce non-native stop clusters, they overwhelmingly tend towards open-schwa transitions (43c.). Stimuli like [zdaba] (recorded by a Czech speaker) were generally repeated by English speakers as [z^{ə}daba]. My account does not determine how these forms are selected over others, but simply states that in terms of their CV representations, [zdaba] and [z^{ə}daba] are identical.

A possible phonological account of this type of loose inter-gestural timing would be to enrich the theory of slots. In this thesis, I adopt a theory of C/V slots, but we do not yet have a good understanding of whether slots can associate with more than just feature bundles. One open possibility is that C-slots can bear associations with other slots. Davidson (2003) is one such theory, where C-slots can bear different kinds of association relations with vowel and other consonant slots. The nature of these C-V and C-C associations are implemented as different kinds of gestural timing relationships.

The reason I do not adopt Davidson's theory of CC association is because it is unclear that these kinds of narrow C-C transitions are ever phonologically contrastive within a single language. The important empirical dataset for this question are Southeast Asian languages that have "minor syllables", where certain CC transitions are either open ($C^{ə}C$) or closed (CC). If the quality of the CC transition is entirely unpredictable in these languages, then there is reason to encode CC transition directly with different kinds of association relations (as in Davidson 2003). If the CC transition can be predicted from other factors, then it may be in our best interest to allow the phonological representation to underspecify the type of CC transition (as in Lamination Theory).

In Khmer, a language with minor syllables, initial evidence suggests that the CC transition type may be predictable. Khmer has CC transitions that are either open ($C^{ə}C$, e.g. [$s^{ə}$noo] 'sound') or closed (CC, e.g. [snae] 'love'). These transitions have been described as unpredictable in previous work (Butler, 2014), because they cannot be predicted from consonant quality alone. However, these words are not minimal pairs from a morphological perspective — [$s^{ə}$noo] has an infixed n, but [snae] is monomorphemic. It is therefore possible that the difference in CC transition is simply reflecting the morpheme boundary, rather than a difference in segmental structure. The Khmer case requires further study — to date, no phonetic study has controlled for morphological boundary type when examining the kinds of CC transitions. My prediction is that for clusters that vary between open ($C^{ə}C$) and closed (CC) transitions, that open transitions only occur with infixes. I set aside the Khmer case for future work, and for the time being, do not directly encode narrow CC timing.

Finally, lamination does not legislate gestural coupling. Gestural coupling is found in a closely related theory to Articulatory Phonology called the Coupled Oscillator model (Nam and Saltzman, 2003; Saltzman and Byrd, 2000). The core proposal is that we can model speech sounds as oscillators, which can be coordinated (or "coupled") so that they begin in unison (in-phase) or at different times (out-of-phase). Coupling has its empirical basis in research on motor planning, where in-phase coordination is preferred at higher rates of motion. Lamination does not specify anything about intergestural timing or coupling — it only encodes overlap, precedence, and containment. I treat coupling as a purely phonetic effect, driven by extra-linguistic motor planning concerns.

2.3.5 Quick Summary: Principles of Lamination

There are five rules that govern how phonological representations are transformed into gestural scores. The last two (*The Law of Order Preservation* and *The Law of Specified Gestures*) represent how the phonetics encodes two persistent properties of the timing layer. These are universal properties of lamination, the component of grammar that transforms metamorph and timing layer representations into linearized, pronounceable gestures.

(45) RULE 1. SEGMENT REALIZATION. If a segment is present in the metamorph layer, then there must be some gesture that corresponds to it.

(46) RULE 2. OVERLAP. 'When slots and features are associated, they must overlap in time' (cf. Sagey 1988)

(47) RULE 3. VOWEL SLOT CONTIGUITY. 'When two V-slots have no other V-slots between them, they must be contiguous' (cf. Browman & Goldstein 1990: 12)

(48) RULE 4. ORDER PRESERVATION. 'When a segment or slot precedes another in the input, the first must start first, or the last must end last'

(49) RULE 5: THE LAW OF SPECIFIED GESTURES. When one gesture contains another, the gesture of the more specified segment must contain the gesture of the less-specified segment.

For the analysis later on, the vital takeaway here is that line-crossing produces *nested gestures*. If segment A crosses over segment B, then the gesture of A must *contain* B. This will prove to be an important result in the typology of metathesis (Chapter 3), which is that fully general patterns produce incomplete (nested) outputs.

I now go on to discuss two broader predictions of my theory for phonetic gradience (Section

2.4) and phonological invisibility (Section 2.5). Later on, these properties will become my primary diagnostics for identifying language-general versus morphologically-restricted patterns.

2.4 Phonetic gradience

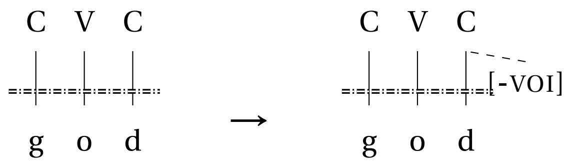
A recurrent issue in phonological theory is that some patterns contain subphonemic variation in their outputs. In German obstruent devoicing, for instance, the realization of /rad/ → [raːt] 'wheel' is gradient and incompletely neutralized in the phonetics (Charles-Luce, 1985; Dinnsen and Charles-Luce, 1984; Port and Crawford, 1989; Port and O'Dell, 1985). German devoiced stops are preceded by a longer vowel, have more voicing into the closure, and have greater frication and voicing on the stop closure than in faithful voiceless stops. The effect is that speakers can identify devoiced stops (relative to voiceless stops) at an above-chance rate (Port and O'Dell, 1985).

Phonetic gradience poses a problem for most theories of generative phonology, since it seems to contradict the categoricity of phonological specifications. If phonetic outputs are gradient, neither matching one feature value or another, then there is the question of how the phonology represents these gradient outputs, if at all.

2.4.1 Gradience in Lamination Theory

Lamination Theory provides a way for us to represent subphonemic gradience without needing to weaken our theory of features. The premise is that subphonemic gradience occurs when the phonetics unifies two representational layers that have conflicting specifications. In Russian obstruent devoicing, for instance, the final C-slot in the timing layer gains a [-VOI] specification. This conflicts with the representation of /d/ in the metamorph layer, which is specified for [+VOI].

(50) Russian devoicing occurs via feature insertion



/god/ 'year' [got] ∼ [go$\mathring{\text{d}}$] 'year'

When the speaker goes to pronounce /d/, the timing layer and metamorph layers are in conflict, forcing the phonetics to use a mix of phonetic cues for specifications of [+VOI] (located in /d/) and [-VOI] (located in the timing layer). Like German, the Russian devoiced obstruents have shorter obstruent closure and a shorter release than their voiceless counterparts (Dmitrieva et al., 2010).

The relationship between gradience and categoricity thus stems from mismatches between phonological layers. The timing output cannot rewrite segments, and so featural additions in the timing layer can contradict those in the metamorph layer. When contradictions arise, the phonetics is forced to split the difference between the timing and metamorph outputs, producing gradient outputs.

2.4.2 Categorical behavior

While Lamination Theory predicts that timing-layer effects can be gradient, it is less decisive on where and when categorical outputs may arise. In principle, categorical behavior can occur from effects in either the metamorph layer or the timing layer.

Let's begin by discussing the metamorph layer. Metamorph-layer mappings involve full rewriting of segments, and so we expect for metamorph-layer effects to always be categorical. In the typology of obstruent devoicing, this appears to be correct — language-general patterns are gradient, whereas morphologically-restricted patterns are categorical. This is shown in Table 2.1.

The result is that morphologically-conditioned phonology always appears to have a categorical output. Recent work suggests this is on the right track: as phonology becomes more mor-

	Language	Lg.-general?	Phonetics complete?	Source
a.	German	✓	✗	(Port and O'Dell, 1985)
	Catalan	✓	✗	Charles-Luce and Dinnsen (1987)
	Dutch	✓	✗	Warner et al. (2004)
	Lithuanian	✓	✗	Campos-Astorkiza (2008)
	Polish	✓	✗	Tieszen (1997)
	Russian	✓	✗	Dmitrieva et al. (2010)
b.	Turkish	✗	✓	Kopkallı (1993)

Table 2.1: Gradience in word-final obstruent devoicing

phologically conditioned, phonetic gradience can disappear. Hall (2017), for instance, observes that in Palestinian Arabic verbal paradigms, morphologically-conditioned vowel shortening is in fact categorical. This contrasts with the language-general vowel epenthesis in Palestinian Arabic, which appears to be phonetically gradient (Gouskova and Hall, 2009). Similar results have also been found in consonants. Seyfarth et al. (2019) find that in Javanese verb paradigms, initial nasalization (a morphologically-conditioned alternation) is categorical. Morrison (2019) also finds that in Scottish Gaelic, initial consonant mutation also produces categorical outputs. All of these patterns are morphologically conditioned and have been demonstrated to *lack* phonetic gradience.

From an initial survey in Table 2.2 (drawing on data from Almihmadi 2011: 296-297), this appears to be correct: Morphologically-conditioned patterns have categorical phonetic behavior.

However, there are persistent cases where language-general effects appear to produce categorical outputs. Some examples include Korean manner neutralization (Kim and Jongman, 1996) and place/nasal assimilation (Kochetov and Pouplier, 2008; Zsiga, 2011), Sardinian assimilation (Ladd et al., 2003), and Spanish nasal assimilation (Honorof, 1999). Exactly how to capture these patterns in Lamination Theory remains unclear. If these patterns are in fact language general, as described, then they should take place in the timing layer. This would suggest that the timing layer can also produce categorical outputs. However, another possibility is that these patterns

Language	Morph.-restricted?	Phonetics complete?	Source
Consonant mutation/nasalization			
Scottish Gaelic	✓	✓	Morrison (2019)
Javanese	✓	✓	Seyfarth et al. (2019)
Consonant assimilation (to form geminates)			
Tashlhiyt Berber	✓	✓	Ridouane (2010)
Bengali	✓	✓	Lahiri and Hankamer (1988)
Vowel deletion/reduction			
Catalan	✓	✓	Herrick (2003)
Shimakonde	✓	✓	Liphola (2001)
Palestinian Arabic	✓	✓	Hall (2017)

Table 2.2: Morphologically-restricted phonology is phonetically categorical

are not as general as they appear. One such possibility is that these patterns only apply to roots or another large (but restricted) morphological class. Under this analysis, then we could again derive these patterns in the metamorph layer, and a categorical output would be expected.

Further work on each of these patterns is needed to determine how to proceed, and so for the time being, I adopt a conservative approach: I assume that phonetic gradience does distinguish between timing-layer and metamorph-layer effects, but only in one direction. Gradient behavior always stems from alternations in the timing layer, but categorical behavior can arise from either.

2.4.3 Gradience in reordering

One major prediction of Lamination Theory is that language-general reordering effects should be phonetically gradient. Specifically, when metathesis and copy epenthesis are fully general, they are expected to bear phonetic cues that indicate displacement has occurred. This is tightly connected to how timing representations with line-crossing are laminated.

As a preview of what incomplete reordering looks like, let us first consider metathesis. Phonetically incomplete metathesis fails to fully reorder the segments, and so a portion of the sound remains pronounced in its original position. To illustrate, consider CV metathesis in Meto (Austronesian, Mooney 2023) and CC metathesis in Andalusian Spanish (Indo-European, Gilbert 2022), shown in (51)-(52) below. (See Chapter 3 for a detailed analysis.)

(51) Language general CV metathesis: Meto /CV/ → VC

	UR	metathesized		bare form
a.	/manus-e/	ˈma͡ʊns-e	'the betel vine'	ˈmanus 'betel vine'
b.	/ʔatoniʔ-es/	ʔaˈto͡inʔ-es	'a man'	ʔaˈtoniʔ 'man'
c.	/ʔasu mutiʔ/	ʔa͡ʊs ˈmutiʔ	'white dog'	ˈʔasu 'dog'

(52) Language-general CC metathesis: Andalusian Spanish /sC/ → Ch

a.	/kastijo/	kathijo	∼ kahtijo	'castle'
b.	/astuto/	athuto	∼ ahtuto	'cunning'
c.	/las patas/	la phatah	∼ lah patah	'the paws'

Phonetic incompleteness often occurs in both of these metathesis patterns, such that the metathesized sound straddles both sides of the intervening one (Gilbert and Mooney, 2022). In Figure 2.6 (a), Meto metathesis is incomplete, where an excrescent [u] to the right of the [n] in /manus-e/ → [ma͡ʊnu̯s-e] 'the betel vine'. In Figure 2.6 (b), Sevillian Spanish metathesis shows the same effect, where the [s] has only partially moved past the [t] in /astuto/ → [astsuto] 'cunning', leaving some frication in its original position.

a. Meto: incomplete metathesis b. Andalusian Spanish: incomplete metathesis

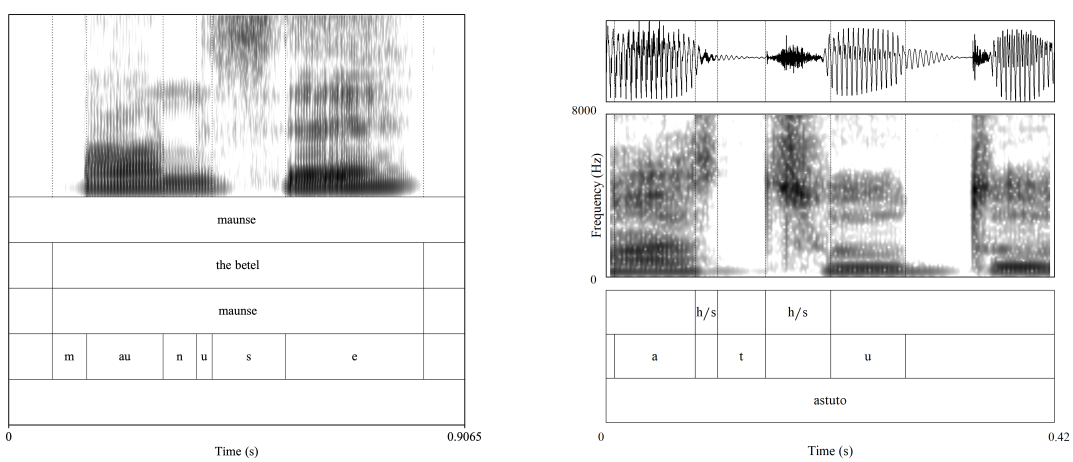


Figure 2.6: Meto and Spanish metathesis can be phonetically incomplete in (a) /manus-e/ → [ma͡ʊnu̯s-e] (vs. complete [ma͡ʊns-e]), and (b) /astuto/ → [as̠tsuto] 'cunning' (vs. complete [atsuto]).

Copy epenthesis shows similar phonetic gradience in some languages. Karlin (2022) describes Finnish copy epenthesis of vowels within heterorganic CC clusters. No epenthesis occurs when the clusters are: (a) homorganic, (b) the first consonant is voiceless, or (c) the cluster is not adjacent to the stressed syllable.

(53) Language-general copy epenthesis: Finnish (Karlin, 2022)

a.	/kahʋi/	ˈkahaʋi	‘coffee’
b.	/helppo/	ˈheleppo	‘easy’
c.	/halpa/	ˈhalapa	‘cheap’
d.	/ahma/	ˈahama	‘wolverine’
e.	/silmæ/	ˈsilimæ	‘eye’

(54) No copy epenthesis when cluster is (a) homorganic, (b) with a voiceless C1, or (c) not stress-adjacent (Karlin, 2022)

a.	/malli/	ˈmalli	‘model’	*ˈmalali
	/ilta/	ˈilta	‘evening’	*ˈilita
b.	/pitkæ/	ˈpitkæ	‘long’	*ˈpitikæ
	/ahkera/	ˈahkera	‘hard-working’	*ˈahakera
c.	/kuvitelma/	ˈkuvitelma	‘fantasy’	*ˈkuviteleima

Finnish copy epenthesis is often phonetically gradient (Karlin, 2022). In Figure 2.7, outputs vary on whether copy epenthesis is (a) present (but with a very short vowel), (b) partial (showing an even shorter vowel with less intensity), or (c) absent entirely.

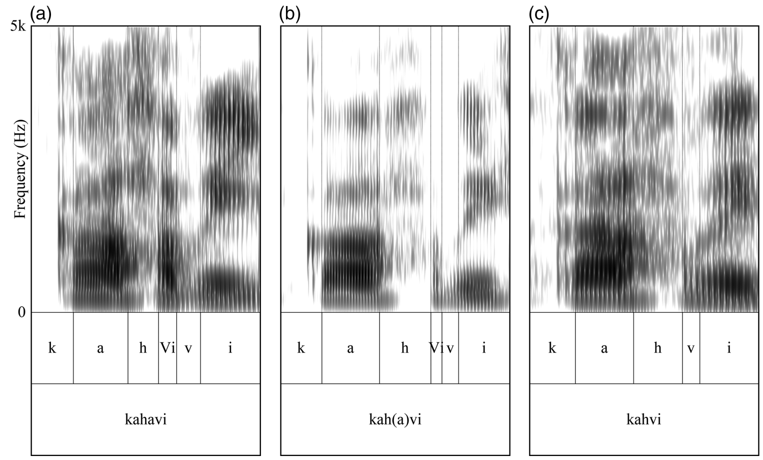


Figure 2.7: Gradient copy epenthesis in /kahvi/ 'coffee' in Finnish from Karlin (2022). The epenthetic vowel is marked with V_i, and gradiently varies between being (a) present, (b) partial, or (c) absent entirely.

This is precisely what we expect in Lamination Theory. Language-general copy epenthesis is derived in the timing layer through line-crossing, and while the exact intergestural timing is underspecified, the expectation is that these representations should create nested gestural outputs (see Section 2.3.3).

There are not many other studies on the phonetic implementation of copy epenthesis, but those that exist observe similar gradience. Li (1973: 51) observes that in Rukai dialects, a word-final epenthetic copy vowel is often short, devoiced, or absent entirely in fast speech. In Ho-Chunk (aka Winnebago, Siouan), Hall et al. (2019) observe that the epenthetic copy vowel has significantly shorter duration than non-epenthesized counterparts. In Marshallese, Bender (1968, :34) reports that "excrescent [copy] vowels between full consonants are reduced in stress to such an extent that they contrast with inherent vowels in similar environments."

In comparison, the behavior of morphologically-restricted metathesis and copy-epenthesis patterns is not well-known. For instance, despite the large volume of typological studies on both infixation (Broselow and McCarthy, 1983; Kalin, 2022; Moravcsik, 2000; Ultan, 1975; Wilson, 2014; Yu, 2007, 2003) and reduplication (Inkelas and Zoll, 2005; Marantz, 1982; Spaelti, 1997; Urbancyzk, 2001; Wilbur, 1973), neither of these phenomena have been reported to be phonetically incomplete. Similarly, morphologically-restricted metathesis and copy epenthesis patterns have no reported phonetic incompleteness (see Chapter 4), though data on these facts is sparse.

Lamination Theory predicts that language-general reordering should produce gradient, gesturally nested outputs. Morphologically-restricted reordering, by comparison, is predicted to produce categorical, phonetically complete outputs. Phonetic gradience thus provides an important diagnostic for identifying timing-layer patterns.

2.4.4 Previous approaches to gradience

The question of how to encode sub-phonemic gradience is an area of active contention among most contemporary theories of phonology. To what degree are sub-phonemic distinctions encoded? How does this relate to featural theories of contrast? At the core of this debate is not simply just a question of what kind of theory we want to build, but also what kinds of data we consider to be phonological. The two are deeply entwined, and so there is considerable variability between theories on how they handle these questions.

There are two extremes in this debate, which I briefly describe here. The first is that phonology does not encode phonetic gradience at all, which I'll call the "representations over reality" approach (Chomsky & Halle 1968: 293, Kenstowicz & Kisseberth 1977, Pierrehumbert 1990, Hale & Reiss 2008, a.o.). In this kind of model, phonology is an abstract system that is largely divorced from implementation. Phonology exists to compute over abstract representations alone. Where phonetic gradience exists, it remains to be explained by the phonetics (Cohn, 1993; Keating, 1988, 1990; Zsiga, 1997, 1993).

The second extreme is that phonology encodes all subphonemic gradience, which I call "matter over mind" (Browman and Goldstein, 1992, 1986; Pierrehumbert, 2000). In matter over mind, there is no abstract representation that is divorced from phonetic fact. The mental representation of phonemes and phonological rules is essentially a statistical distribution of how to pronounce real sounds, and purely abstract representations like binary features or atomic segments only exist insofar as they are a tool for analysts.

There are good arguments behind each of these views. In the representations over reality approach, we prioritize looking at categorical phonological data so that we can make sharp predictions about phonological typology. In the matter over mind approach, we are able to see how structure we previously thought of as purely abstract often *does* play out in granular phonetic detail. For example, morpheme boundaries have been found to affect sub-phonemic gradience in a number of areas, including /l/ darkening (Lee-Kim et al., 2013; Sproat and Fujimura, 1993), stability in CV timing (Cho, 2001 Jul-Sep), and assimilation across morpheme boundaries (Song et al., 2013). In a representations over reality theory, these kinds of discoveries may never have been made, and yet they clearly enrich our knowledge of how language is encoded in real speech.

Most theories occupy a middle ground between representations-over-reality and matter-over-mind approaches. One such middle ground is to appeal to stochastic learning — the output of phonology is discrete, but then passed through a filter that assigns probabilistic weights to the different outcomes (e.g. Stochastic OT, Boersma and Hayes 2001; see also Exemplar Theory, Pierrehumbert et al. 2002). Stochastic models would predict that sub-phonemic gradience is essentially a feedback loop. Historically, conditions arose that introduced greater variation, and speakers replicated that variation until it became an observable effect.

Another middle ground is to hard-code it into the phonology. This can take the form of paradigm uniformity effects (e.g. Steriade 2000, on /t/ flapping; Ernestus & Baayen 2007, on obstruent devoicing), underspecification of phonological outputs (Cohn, 1993; Keating, 1988; Pierrehumbert, 1980), or assigning truly intermediate representations to these gradient outputs (e.g. Van Oostendorp 2008, on obstruent devoicing; Hall 2003, on vowel intrusion). These hard-coded approaches are compatible with recent observations that gestural patterns have access to fine-grained phonological information (e.g. Bennett et al. to appear; Hall 2003).

The approach I adopt here is a hard-coded one. Lamination Theory captures sub-phonemic gradience by leveraging its representational assumptions, using a mix of underspecification (for precedence, Section 2.4.3) and intermediate representations (for conflicting feature values, Section 2.4.1). Gradience is no accident of the system, but instead a kind of unavoidable compromise that is needed to transform abstract, bi-dimensional representations into phonetic ones.

2.5 Invisibility

In this section, I turn to another important property that distinguishes language-general reordering patterns: invisibility. Invisibility refers to a certain kind of phonological inertness — even when a phonological alternation occurs, other phonology (such as stress, reduplication, allomorphy) all behave as if no change has taken place (Hall, 2003, 2006). Lamination Theory allows us to capture phonological invisibility by leveraging the split representations of the timing and metamorph layer.

As an example of what phonological invisibility looks like, consider copy epenthesis in Kĩsêdjê (Macro-Je, Nonato 2014, Beauchamp 2019). When utterances end in a consonant, the preceding vowel copies: Oral vowels copy across oral consonants, and nasal vowels copy across nasal consonants and [r].[12] This is illustrated in (55):

(55) Copy epenthesis in Kĩsêdjê (Nonato 2014: 129)

Oral vowels copy across oral consonants			Nasal vowels copy across nasals and [r]		
a. /ŋɹot/	ˈŋgɹoɾo	‘the Pleiades’	e. /hrɔ̃n/	ˈhrɔ̃nɔ̃	‘to run’
b. /tʰɛp/	ˈtʰɛwɛ	‘fish’	f. /kʰɛ̃n/	ˈkʰɛ̃nɛ̃	‘rock’
c. /mɨt/	ˈmbɨɾɨ	‘to cry’	g. /tũn/	tũnũ	‘to argue’
d. /mɘr/	ˈmbɘrɘ	‘to cry’	h. /ŋɔ̃r/	ŋɔ̃rɔ̃	‘to sleep’

The Kĩsêdjê pattern is *invisible* with respect to stress assignment. Stress uniformly falls falls on the final syllable of a word (e.g. [saˈɾɛ̃] ‘to say’), but when there is epenthesis, it falls on the penult (Nonato 2014: 130). Stress is thus blind to the fact that the copy vowel exists. [13]

[12] If an oral vowel is followed by a nasal consonant, copy epenthesis is blocked and a default [i/ɨ] is inserted. Same goes for nasal vowels followed by oral consonants other than [r]. See discussion in Chapter 4.

[13] Similar effects have been observed for Selayarese (Kitto and de Lacy, 1999; Mithun and Basri, 1986; Stanton and Zukoff, 2018) and Italian (Repetti 2012: 176), which both have copy epenthesis in loanword adaptation. Note, however, that previous accounts have analyzed Selayarese in different terms. Stanton and Zukoff (2018), for example, analyze a similar pattern in Selayarese as a prosodic identity effect between copy vowel and host. I discuss this alternative in Chapter 4.

Another example of invisibility occurs with phonologically-conditioned allomorphy. In Meto (Austronesian, Mooney 2023), the plural suffix has three allomorphs: /-n/ after single vowels, /-in/ after consonants, and /nu(k)/ after two vowels.

(56) Plural allomorphy in Meto

/-n/ after V#		/-in/ after C#		/-nu(k)/ after VV#	
/tasi/	[tasi-n] 'sea-PL'	/tais/	[ta͡is-in] 'sarong-PL'	/fai/	[fa͡i-nuk] 'nights'
/ʔasu/	[ʔasu-n] 'dog-PL'	/manus/	[ma͡uns-in] 'betel-PL'	/ʔao/	[ʔa͡o-nuk] 'bodies'

When additional suffixes are added, metathesis occurs for prosodic reasons in CVCV stems. But, metathesis does not change allomorph selection, despite the stem now being consonant-final:

(57) Meto metathesis is invisible to allomorphy

/ʔasu-n-e/ [ʔa͡us-n-e] 'dog-PL-DEF' *[ʔa͡us-in-e]

In this way, metathesis is invisible to allomorph selection — the application of metathesis has no bearing on the allomorph selected, even when another allomorph would be expected given the surface structure.

Similar invisibility effects are also found in Finnish copy epenthesis (Hall, 2003; Karlin, 2022). The Finnish partitive has two allomorphs that depend on stem size. Disyllables take /-oja/ (replacing the final syllable of the vowel) and larger stems take /-oita/, as in (58).

(58) Finnish partitive allomorphy is conditioned by stem size (Karlin, 2022)

a. Disyllabic stems take /-oja/			b. Larger stems take /-oita/		
/kala/	[kaloja]	'fish.PRT'	/lakana/	[lakanoita]	'sheet.PRT'

Hall (2003) and Karlin (2022) argue that copy epenthesis is invisible to allomorph selection. Disyllabic stems uniformly select /-oja/ even when copy epenthesis makes them appear trisyllabic.

(59) /ahma/ [ahama] 'wolverine'

[ahamoja] 'wolverine.PRT' *[ahamoita] (Karlin 2022)

/ohra/	[ohora]	‘barley’	
	[ohoroja]	‘barley.PRT’	*[ohoroita]

Not all phonology is invisible to allomorph selection. Reduplication, for instance, regularly feeds allomorph selection, even when based on stem size. For an example, consider locative allomorphy in Yinjibarndi (Stanton, 2022). In Yindjibarndi, there are two allomorphs for the locative, /-ŋga/ and /-la]/, as in (60). These two allomorphs are conditioned by the size of the stem, with /-ŋga/ occurring after disyllables, and /-la]/ occurring after larger stems:

(60) Yindjibarndi locative allomorphy is conditioned by stem size (Stanton, 2022)

a. Disyllabic stems take /-ŋga/		b. Larger stems take /-la/	
malu-ŋga	‘shade-LOC’	paɹkara-la	‘plain-LOC’
ŋura-ŋga	‘ground-LOC’	kupica-la-ŋu	‘small-LOC-ABL’
t̻ama-ŋga	‘fire-LOC’	piʈat̻a-la	‘dry.leaf-LOC’

Is Yindjibarndi reduplication phonologically visible? We can test this by placing a reduplicative suffix on a disyllabic stem. If reduplication is like Finnish copy epenthesis, then we expect that the bare stem and the stem with the reduplicant will both take the same allomorph, /-ŋga/. However, if reduplication is visible to allomorph selection, then they should take different allomorphs: the bare stem should take /-ŋga/, and the reduplicated stem should take /-la/. The latter is true: reduplicated stems and bare stems take different allomorphs, as in (61). Reduplication is visible to allomorph selection in Yindjibarndi.

(61) Yindjibarndi reduplication feeds allomorph selection (Wordick 1982: 132)

a. Bare stem selects -ŋga

waru-ŋga-mu	‘tomorrow’	(stem is two syllables)
night-LOC-ANA		

b. Reduplicated stem selects -la

waru-waru-la-mu	‘first light’	(stem is four syllables)
night-RED-LOC-ANA		

It's worth asking here if the visibility of reduplication here is specific to Yindjibarndi, or if it reflects something more general about phonological grammar. This is an open empirical question. At this time, I know of no cases where reduplication fails to feed allomorph selection, and so I put forward a hypothesis for a universal: reduplication is always visible to allomorphy. Later on, in Chapters 3 and 5, I argue that morphologically-restricted metathesis and morphologically-restricted consonant epenthesis are likewise always phonologically visible, unlike their language-general counterparts.

2.5.1 Deriving invisibility

There are two ways that we can derive invisibility in Lamination Theory. The first way is serialism, where metamorph representations are evaluated before timing-layer ones. This solution is both elegant and simple, and for readers who'd like to continue onwards, I recommend just assuming serialism and proceeding directly to Section 2.6. However, there are other ways of deriving invisibility without a serial analysis that I believe have yet to be explored. In this section, I sketch out one such possibility.

Lamination Theory can derive invisibility through a restriction on CON: Metamorph-layer constraints cannot reference the timing layer, nor can they be dominated by timing-layer constraints. I define this as the Blindness Condition in (62):

(62) **Blindness Condition for Metamorph CON**

a. Metamorph-layer constraints (that reference particular morphemes) can never make reference to timing slots or association lines. They can only reference segments and prosodic information.

b. Metamorph-layer constraints can only be dominated by other metamorph-layer constraints.

By contrast, timing CON has no such restriction: it can make reference to *any* layer of the representation. (Note, however, that timing GEN can still only change slots and association. There is thus a mismatch between what the timing layer can see versus what it can do.)

To illustrate, let us return to the Meto allomorphy cases from (56)-(57) above. Recall, the main pattern is that the plural suffix appears as /-n/ after V# roots, /-in/ after C# roots, and /-nu(k)/ after VV# roots. When metathesis occurs (reproduced in (63) below), the allomorph selected is consistent with the underlying form, rather than the surface one.

(63) Meto metathesis is invisible to allomorph selection *reproduced from (57)*

/ʔasu-n-e/ [ʔa͡us-n-e] 'dog-PL-DEF' *[ʔa͡us-in-e]

We can model the invisibility of Meto metathesis as an interaction between PRIORITY (following Mascaró 2007) and *[+CONS][+CONS]. In bare stems (66), the allomorph /-in/ is selected to avoid consonant clusters.

(64) PRIORITY: 'Respect lexical priority (ordering) of allomorphs'
Given an input containing allomorphs $m_1, m_2, \ldots, m_n$, and a candidate $m_i{}'$, where $m_i{}'$ is in correspondence with m_i, PRIORITY assigns as many violation marks as the depth of ordering between m_i and the highest dominating morph(s). (Mascaró, 2007)

(65) *[+CONS][+CONS]: Assign a violation for two consonantal segments that are not immediately followed by a non-consonantal segment.

(66)

/ʔasu-{n, in}/	*[+CONS][+CONS]	PRIORITY
☞ a. ʔasu-n		
b. ʔasu-in		*!

(67)

/manus-{n, in}/	*[+CONS][+CONS]	PRIORITY
a. manus-n	*!	
☞ b. manus-in		*

The PRIORITY and *[+CONS][+CONS] are constraints that reference the metamorph layer, and so they must satisfy the first clause of the Blindness Condition: they cannot reference the timing layer. This is true. Neither slots nor association lines are referenced in the definition of PRIORITY and *[+CONS][+CONS].

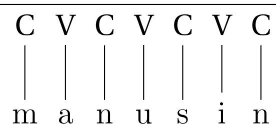
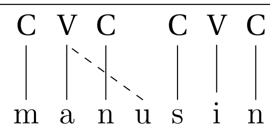
The Blindness Condition also requires that PRIORITY and *[+CONS][+CONS] are not dominated by timing-layer constraints. The two timing-layer constraints at play here are ALIGN(X,R) and *LINECROSS, as defined in (68)-(69) below. These two timing layer constraints are dominated by the metamorph ones, shown in (70).

(68) ALIGN(X,R): Assign a violation for every V-slot between the stress and the right edge of the phonological phrase.

(69) *LINECROSS: 'Don't let association lines cross'

Assign a violation for each pair of crossed association lines.

(70)

/manus-{n, in}/	PRIORITY	ALIGN(X,R)	*LINECROSS
a. 	*	**!	
☞ b. 	*	*	*

The critical ranking here is that *[+CONS][+CONS] outranks ALIGN(X,R). If the opposite ranking were used, we would derive the /-n/ allomorph across the board. The second clause Blindness Condition fully eliminates this possibility by prohibiting timing-layer constraints from dominating metamorph layer ones.

Is the second clause of the Blindness condition necessary to derive invisibility? Suppose we defined *[+CONS][+CONS] as a timing-layer constraint and allowed it to dominate PRIORITY. This ranking produces the correct effects for bare stems (71a.), but incorrectly derives phonological *visibility* in (71b.).

(71) Invisibility is lost if we allow timing-layer constraints to be ranked high (violating (62b.) of the *Blindness Condition*)

a.

/ʔasu-{n, in}/	*CC	PRIORITY
☞ a. C V C V - C ; ʔ a s u n ; [ʔasu-n]		
b. C V C V - V C ; ʔ a s u i n ; [ʔasu-in]		*!

b.

/ʔasu-{n, in}-e/	*CC	PRIORITY
☹ a. C V C - C - V ; ʔ a s u n e ; [ʔa͡us-n-e]	*!	
💣 b. C V C - V C - V ; ʔ a s u i n e ; [ʔa͡us-in-e]		*

The invisibility of the timing layer thus needs separate restrictions on (i) what constraints compose metamorph CON and (ii) how metamorph constraints may be ranked relative to timing layer ones.

2.6 Local Summary

To sum up, there are three properties that I use to distinguish timing layer phonology from metamorph phonology: morphological restrictions, phonetic gradience, and phonological visibility.

1. **Morphological restrictions.**
   I assume that only the metamorph layer has access to morpheme identity. The consequence of this is that only metamorph patterns should be able to be restricted to certain morphemes. The timing layer, in comparison, can access segments, slots, and abstract

boundaries (including prosodic and morpheme boundaries), but it cannot access the kinds of morphemes within them.

Heuristic: If we state the pattern in terms of sound and boundaries alone, are there still surface exceptions? If yes, it must be a metamorph layer pattern. If no, undetermined, but likely timing layer.

2. **Phonetic gradience.** (Section 2.4)
   The second diagnostic I use is phonetic gradience. While much phonology produces categorical results, some phonology is gradient, where phonetic imprints of the input are observable in the output. I assume that only the timing layer can produce gradient outcomes, because gradient outcomes are derived via mismatches between representational layers. In comparison, the metamorph layer does fully rewrite inputs, and so mismatch is impossible.

   Heuristic: Can we identify what the underlying form must be from cues in the phonetics? If yes, it must be a timing layer pattern. If no, it may be either a timing-layer or a metamorph-layer pattern. This diagnostic comes with a caveat that such effects may be quite small, and so dedicated acoustic studies are expected to be necessary to confirm the presence or absence of an effect.

3. **Phonological visibility.** (Section 2.5)
   One way to assess if an abstract phonological change has occurred is if it is visible other phonology, such as stress assignment (Hall 2006), reduplication (Hall 2003: 80), allomorphy (Hall 2003: 57, 71), or morpheme structure constraints like word minimality (Hall 2003: 84-85). Following Hall (2003), I assume that each of these phenomena use segmental representations for calculating outputs. The expectation is that only metamorph layer patterns will be visible to other phonology, because only the metamorph layer manipulates segments.

   Heuristic: Are other (morpho-)phonological patterns conditioned by the outcome? (Specifically: stress assignment, reduplication, infixation, word minimality, or phonologically-conditioned allomorphy?) If yes, then it must be a metamorph layer pattern. If no, then it could be either a timing-layer or a metamorph-layer pattern.

2.6.1 A note on learning

Lamination Theory may appear as if it could pose problems for phonological learning, since now learners would be required to not just discover the correct patterns, but also select the correct grammar to derive them. However, I argue that this isn't necessarily true. Proposals that assume a bifurcated phonology can also be understood as modeling learners that use heterogeneous learning strategies.

Concretely, I propose that learners have two ways of learning phonological patterns: one way over morphologically related forms, and another way that only has access to sound and boundaries. ("Paradigmatic learning" for morphologically-restricted patterns and "syntagmatic learning" for language-general patterns.) Crucially, these two learning strategies do not produce the same patterns. Segmental reordering is *only* learnable from comparing morphologically-related forms in the paradigmatic strategy. In comparison, general patterns that do not fully reorder segments (and instead extend or displace surrounding gestures) are learned from relatively unstructured syntagmatic data.

If learning strategies are heterogeneous in this way, we also may expect for these learning strategies to have inherent biases towards certain types of evidence. In the paradigmatic learning strategy, for example, mismatches between the allomorph selected and surface form (such as the invisibility cases from Section 2.5) may have stronger effects, leading speakers to adopt a UR that requires less opacity. In comparison, if speakers are aggregating tokens from a variety of syntagmatic contexts, then we might expect these same kinds of allomorph-surface mismatches to be less salient, but for say, sub-phonemic cues to be privileged.

Adopting a bifurcated model of grammar opens up additional possibilities in modeling phonological learning, and it's not clear which theory would be more restrictive. If learners have different strategies for each kind of phonological grammar, then we expect that the structure of the data is just as important as the pattern for how speakers analyze it. It should therefore be possible to bias learners towards one kind of strategy over another by manipulating the phonetic, phonological, and morpho-phonological cues in the input.

2.7 Conclusion

The core proposal of Lamination Theory is that phonology is not uniform. When we consider phonological patterns that are language-general and those that are conditioned by particular morphemes, we find that these two classes of phonology are not homogeneous. Language-general patterns appear to be based in articulatory timing and must preserve order, whereas morphologically-restricted patterns may fully rewrite, reorder, and copy at a distance in a way that general patterns cannot.

The timing layer and the metamorph layer are different representational sides of phonological strings, assessed by different constraints and manipulated by GEN following different rules. Whether they are also separated into different grammatical components is a different question, one that I leave open.

In Chapter 3, I demonstrate that language-general metathesis patterns are always a kind of gestural nesting, whereas morphologically-restricted patterns may fully reorder.Chapter 4 turns to copying patterns, and demonstrates that copying at a distance is always morphologically restricted. Lastly, Chapter 5 then turns to consonant epenthesis patterns, and argues that language-general epenthesis is gestural, and transforms existing sounds into epenthetic consonants. In comparison, morphologically restricted epenthesis is true insertion, and as such is capable of inserting a much wider range of qualities. Chapter 6 concludes.

Chapter 3

Metathesis

Metathesis poses typological and formal problems for phonological theory. Typologically, it's rare. Not many languages have productive metathesis patterns, and even among those that do, metathesis is often morphologically restricted.

An example of morphologically-restricted metathesis comes from Georgian (Butskhrikidze, 2002). In the infinitive, /rv/ sequences metathesize to [vr] and the stem vowel deletes, as in (72). However, this pattern is restricted to the infinitive combining with certain roots — in other root-affix combinations there is no metathesis, nor does the vowel delete, as in (73):

(72) Georgian metathesis with infinitival -v (Butskhrikidze, 2002)

a.	/k'ar-v-a/	→ k'vr-a	'to bind (inf)'
b.	/xar-v-a/	→ xvr-a	'to gnaw (inf)'
c.	/sxal-v-a/	→ sxvl-a	'to chop off (inf)'
d.	/jer-v-a/	→ jvr-a	'to move (inf)'

(73) But not all words metathesize (Butskhrikidze 2002: 94, 187)

a.	/k'er-v-a/	→ k'erv-a	'to sew (inf)'	*k'vra (cf. 72a.)
b.	/ber-v-a/	→ ber-v-a	'blow up (inf)'	*bvra
c.	/da-par-v-a/	→ da-par-v-a	'to hide (inf)'	*da-pvra

In comparison, language-general patterns of metathesis do appear to exist, but are considerably rarer. An example of such a language-general pattern is Nivaĉle, a Matacoan-Mataguayan language spoken in Paraguay. Metathesis in Nivaĉle is pervasive across the language, metathesizing /CV/ to [VC] to avoid words ending in a consonant cluster (74a.) and sonority plateaux at morpheme boundaries (74b.-e.).

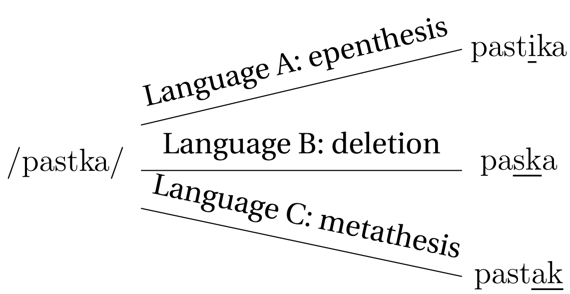
(74) Nivaĉle metathesis VC → CV (Gutiérrez, 2020, : 293)

a.	/finax-s/	finxa-s	'crab-PL'	cf. finax	'crab'	*x-s
b.	/paset-s/	paste-s	'lip-PL'	paset	'lip'	*t-s
c.	/fin-ɑk-nax/	fin-kɑ-nax	'smoker'	fin-ɑk	'tobacco'	*k-n
d.	/ji-kɑjiʃ-nuk/	ji-kɑjʃi-nuk	'my necklace'	ji-kɑjiʃ	'my neck'	*ʃ-n
e.	/namat͡ʃ-waʃ/	namt͡ʃa-waʃ	'axe-mark'	namat͡ʃ	'axe'	*tʃ-w

The typology of metathesis is therefore twice restricted: Few languages have it, and fewer yet have it in a general fashion.

The typological restrictions on metathesis have led to a formal problem: do transposition rules exist? Transposition rules represent an overgeneration problem for both rule-based and constraint-based grammars (McCarthy, 2000; Mooney, 2023; Takahashi, 2019; Webb, 1974). The observation is that if transposition rules exist, then there should be languages that apply them frequently, much like epenthesis or deletion.

(75)



Languages like (75c.) are rare, if they exist at all. Even in languages with general patterns, metathesis often occurs in just a few contexts, such as to remove illicit CC clusters (Faroese, Hume & Seo 2004; Lithuanian, Hume & Seo 2004; Andalusian Spanish, Ruch 2008, Gilbert 2022), syllable contact (Sidaama, Gouskova 2004; Nivacle, Gutierrez 2020) or to improve prosodic well-formedness (Rotuman, McCarthy 1995; 2000; Meto, Mooney 2023). Languages do not appear to use metathesis for all of these things at once, but only select a subset, often using deletion or epenthesis elsewhere.

In this chapter, I address several questions concerning the typology of metathesis:

(76) **Three core questions**

a. Why is metathesis so rare, when it is so simple to describe?

   Answer: General metathesis is not a simple transposition mechanism, but the combination of slot deletion and spreading in the timing layer. Languages need to have both of these operations in the same environment in order for metathesis to arise.

b. Why are most metathesis patterns morphologically restricted? Does the typology of morphologically-restricted metathesis differ from the general patterns?

   Answer: Morphologically-restricted metathesis occurs in the metamorph layer, which can freely transpose segments. Segmental transposition does not have the same restrictions as spreading, and may involve arbitrary consonant qualities.

c. What does the typology of metathesis tell us about precedence in phonology?

   Answer: Segments only reorder in morphologically-restricted alternations. Language-general phonology is Order Preserving; we can apply diagnostics from Hall (2003, 2006) to confirm that general metathesis patterns do not change segmental order.

The aim of this chapter is both empirical and formal. Empirically, I examine a range of language-general and morphologically-restricted metathesis patterns in a typological survey and several in-depth case studies. I claim that these typologies are distinct.

I claim language-general metathesis is gestural overlap, not transposition of segments. Phonetic and phonological diagnostics support this: in language-general patterns, there are cues that indicate sounds have not fully reordered. By contrast, morphologically-restricted metathesis does appear to fully transpose. The typology of metathesis is thus split into patterns that reorder by stretching gestures and patterns that reorder by transposing sounds.

Formally, I analyze the split typology of metathesis in terms of Lamination Theory. Language-general phonology occurs in the timing layer, which cannot transpose. Spreading is thus the only way to generate any kind of reordering, and this comes with limits. Morphologically restricted phonology, on the other hand, occurs in in the metamorph layer, which is capable of complete transposition.

3.0.1 Roadmap

The chapter is structured as follows. Section 3.1 discusses problems with transposition rules, including overgeneration and undergeneration. Section 3.2 provides a typological survey that confirms the rarity of metathesis. Section 3.3 introduces the analysis. Section 4 provides case studies of language-general metathesis, and Section 5 contrasts these with case studies of morphologically-restricted metathesis. Section 6 discusses remaining issues and alternatives. Section 7 concludes.

3.1 The problem of transposition

This section discusses some formal problems in the typology of metathesis: overgeneration (*Vowel-Vowel* and *Long-Distance Problems*, Section 3.1.1) and undergeneration (phonetic incompleteness, Section 3.1.2). Those familiar with these problems can skip these sections, and proceed straight to Section 3.2 on the typological survey results.

3.1.1 Overgeneration: too much transposition

Transposition poses well-known overgeneration issues in phonological typology. The intuitive problem is this: if phonology can transpose, why don't more languages do it?

In rule based grammars, metathesis rules have been in play dating back to the Sound Pattern of English. Chomsky & Halle (1968: 361) proposed a metathesis rule for Kasem, which required a new kind of rule in the *SPE* (e.g. 1 2 3 → 1 3 2). This strengthened the formalism significantly, and intuitively suggests that other kinds of full reordering should be possible. Chomsky and Halle (1968) were well-aware of this, but argued that metathesis is "a perfectly common phonological process (p361)."

Webb (1974) claimed that these kinds of transposition rules misrepresent the synchronic typology. Based on a detailed series of case studies, Webb argued that "synchronic metathesis is not a phonological process. In the residual examples of metathesis, the rule is always morphologically restricted." This was coming at a time when morphological and phonological rules were still separated,[14] and so this claim was very similar to the one I make: that language-general and morphologically-restricted phonology are distinct. However, as the distinctions between morpho-phonology and phonology were blurred in the SPE (Chomsky and Halle, 1968) and subsequent work, Webb's claim largely fell by the wayside. Metathesis alternations were once again analyzed purely in terms of sound, where their morphological restrictions being considered a descriptive issue rather than a substantive formal one (e.g. Buckley, 2007; Hume, 1991, 1998).

Constraint-based grammars largely inherited these problems, which have become an area of repeated debate over the years (Carpenter, 2002; Heinz, 2005b; Hume, 2001; McCarthy, 1995, 2000; Mooney, 2023; Takahashi, 2019). In classic Parallel OT, metathesis is militated against by the faithfulness constraint LINEARITY:

(77) LINEARITY: S_1 is consistent with the precedence structure of S_1, and vice versa.
Let x, y $\in S_1$ and x', y' $\in S_2$. If x $\Re$ x', y $\Re$ y', then x $\prec$ y iff $\neg$ (y' $\prec$ x').

(McCarthy & Prince 1995: 123)

When LINEARITY is dominated, segments may be realized in unfaithful orders. The classic example of a language with dominated LINEARITY is Rotuman (Oceanic, Churchward 1940, McCarthy 1995). Rotuman roots have "complete" and "incomplete" forms that differ in metathesis, shown in (78):

[14] Such as morphophonemic vs. phonemic rules, Swadesh & Voegelin (1939); morpholexical vs. morphophonemic rules, Matthews 1972, Sommerstein 1975.

(78) Rotuman metathesis (Churchward 1940, McCarthy 1995: 2)

	UR	phrase-final	phrase-medial	gloss
a.	/iʔa/	[iʔa]	[iaʔ]	'fish'
b.	/seseva/	[seseva]	[seseav]	'erroneous'
c.	/hosa/	[hosa]	[hoas]	'flower'
d.	/pure/	[pure]	[puer]	'to rule'

The ranking for a language like Rotuman would be along the lines of (79):

(79)

/pure/	MARKEDNESS	MAX	LIN
a. pure	*!		
☞ b. puer			*
c. pur		*!	

McCarthy (1995) observes a snag for this simple account, however. When vowels fall in sonority the vowel deletes, as in (80), instead of metathesizing.

(80) Rotuman metathesis (Churchward 1940; McCarthy 1995: 2)

	UR	phrase-final	phrase-medial	gloss
a.	/rako/	[rako]	[rak]	'fish'
b.	/tiʔu/	[tiʔu]	[tiʔ]	'big'

The issue here is that if LINEARITY is dominated, why not just metathesize twice, as in (81)?

(81)

/rako/	MARKEDNESS	MAX	LIN
a. rako	*!		
b. raok	*!		*
☹ c. rak		*!	
💣 d. roak			**

Again, a typological problem arises. Vowel-vowel metathesis is unattested in synchronic grammars (Hume, 2004). The existence of long-distance metathesis (where the two segments are not adjacent) is similarly dubious. (The one counterexample that has been claimed to exist is Mutsun (Carpenter, 2002), which metathesizes the plural from /mak/ to [kma]. Only the plural suffix does this. See Section 3.6.3.2 for discussion.) However, any account that suggests transposition is freely available predicts both of them easily. I dub these the *Vowel-Vowel problem* and the *Long-Distance problem*, as in (82):

(82) Two overgeneration problems in the typology of metathesis

a. **VOWEL-VOWEL PROBLEM:** No language productively metathesizes two vowels.

b. **LONG-DISTANCE PROBLEM:** No language productively metathesizes non-adjacent segments.

The Long-Distance Problem in particular predicts a number of more concerning patterns outside of Rotuman. To give a taste, here is one such pattern which I dub *nasal magnetism.*

In nasal magnetism, we have a language that allows consonant clusters, but only between a homoorganic nasal and obstruent. Under suffixation, shown in (83), the language avoids illicit clusters by shifting a nasal to the closest available homoorganic stop, no matter how far away it is. The landing site of the nasal is dependent on the place of the affix *and* the shape of the stem. Coronal suffixes will gravitate to other coronals (83a.), but will surface faithfully at the end of vowel-final words (e.g. [pa-n̲]. Similarly, labials will gravitate towards other labials (83b.), but in vowel-final words there is no need to displace.

(83) Long-Distance Problem: Nasal magnetism of suffix/infix (hypothetical data; unattested

pattern!)

	UR	unaffixed	with suffix
a.	/tapama-n/	tapama	tapaman
	/pat-n/	pat	pant
	/tabal-n/	tabal	ntabal
	/patakak-n/	patakak	pantakak
b.	/patapa-m/	patapa	patapam
	/kapat-m/	kapat	kampat
	/tatap-m/	tatap	tatamp
	/tata-m/	tata	tatam

(84) Long-Distance Problem: Transposition derives nasal magnetism

/kapat-m/	*[+CONS][+NAS]	SHAREPLACE	LIN
a. kapat-m	*!	*	
b. kapamt		*!	*
c. kapmat	*!		**
☞ d. kampat			***
e. kmapat	*!		****

If LIN can be dominated, as in (84), then it should be easy to derive this kind of pattern. Yet, no such pattern exists. While nasal magnetism may appear similar to infixation, there are notable differences: nasal magnetism is not limited to one affix, nor is the landing site predictable.

Nasal magnetism is just one pattern that the theory overgenerates, but it is meant to showcase the severity of the long-distance problem. Languages like this don't simply look unlikely, they look ridiculous. Yet, models with transposition derive them easily without further restrictions.

There are many ways to restrict the theory, but few that make it farther than simply restating the facts. For the *Vowel-Vowel Problem*, McCarthy (1995) suggests a kind of prosodic faith (HEADMATCH), which requires prosodic heads to be identical in input and output in Rotuman. However, this turns the absence of vowel-vowel metathesis into a quirk of Rotuman, rather than a universal. Another possibility is to make a higher-ranked faithfulness constraint specific to reordering vowels. This is the tactic taken in Heinz (2005b), who proposes undominated CONTIGUITY-MAXVV for Kwara'ae ("input vowels must have the same contiguity as the input"). However, having CONTIGUITY as a rankable faithfulness constraint implies that the avoidance of vowel-vowel metathesis should be specific to Kwara'ae, not a universal.

The *Long-Distance Problem* has received similar fixes. Horwood (2004) argues in favor of an undominated constraint LIN_2, a version of LINEARITY created via constraint conjunction (Smolensky, 1995). LIN_2 assigns a violation whenever LINEARITY is violated twice for a single segment. Later on, I'll demonstrate that solution is both too weak and too strong: sounds can appear farther than one segment away from their original position (De'kwana, Section 3.6), but these cases are still *gesturally* local, even if they are not segmentally local.

As an aside, other theories have claimed to constrain the typology of metathesis by recasting LINEARITY in adjacency-based terms (e.g. IO-ADJACENCY, Carpenter 2002; CONTIGUITY, Heinz 2005a). Instead of counting precedence changes, these constraints count changes to adjacency (e.g. hypothetical /pati/ → [pait] has one violation, because now [i] is adjacent to [a]. It should be clear that these adjacency-based alternatives accomplish nothing in terms of eliminating long-distance and vowel-vowel metathesis. The exact name or content of the constraint do nothing here — candidates with multiple violations of these constraints should still win when the constraints are dominated. These alternatives thus miss the point, and incorrectly suggest that vowel-vowel metathesis and long-distance metathesis should both still be possible.

The problem, it seems, is with GEN, the component of grammar that generates candidates for evaluation (Mooney, 2023; Takahashi, 2018, 2019). If we remove transposition from GEN, then we are able to stem these overgeneration problems at their source. Takahashi (2018, 2019) advocates for one such model in Harmonic Serialism, where GEN can fuse and split in a single round (violating UNIFORMITY and INTEGRITY), but not transpose. The *Long-Distance* problem is thus resolved through the stepwise derivational scheme of Harmonic Serialism. Mooney (2023) has an alternate proposal, where inputs are enriched with CV skeleta so that spreading is possible, but again transposition is not. In this case, the *Long-Distance* and *Vowel-Vowel* problems are resolved through universal constraints on spreading.

Here I'll be arguing in favor of the implementation in Mooney (2023), where Gen does not allow transposition but does allow spreading. There is no violable Linearity constraint in either proposal, because there is no operation in Gen for such a constraint to rule out. Or, put another way, Linearity is an inviolable constraint on Gen — specifically, timing Gen. I demonstrate that this resolves the *Vowel-Vowel Problem* and the *Long-Distance Problem* in Section 3.6. I return to Takahashi (2019)'s alternative in Section 3.7, and argue that this alternative fails to predict the correct range of phonetic and phonological facts for metathesis in Meto.

3.1.2 Undergeneration: incomplete metathesis

It may come as a surprise that accounts allowing transposition also undergenerate the typology. Recently it has been observed that many languages have phonetically incomplete metathesis (e.g. Foster 1982, Heinz 2005a, Gilbert & Mooney 2022). When two segments metathesize, they fail to reorder fully, resulting in part of the sound occurring on both sides of the intervening one:[15]

[15]Note that the De'kwana example /aːʔdewʔke/ → [aːʔdewʔkwe] 'speech' appears to produce long-distance metathesis! This is the only example of its kind. I discuss it in more detail (and the consequences this has for long-distance metathesis) in Section 3.6

(85) Phonetically incomplete metathesis in different languages

a. **Meto CV → VC** (Mooney, 2023)

/manus-es/	→ ˈma͡ʊnu̯s-es	∼ ma͡ʊns-es	‘a betel vine’
/mepo/	→ ˈme͡opo̯	∼ me͡op	‘work (phr.-medial)’
/tasi/	→ ˈta͡isʲ	∼ ta͡is	‘sea (phr.-medial)’

b. **Kwara’ae CV → VC** (Heinz 2005a: 2, 33-37)

/leʔa/	→ le̯aˈʔa	∼ ˈle̯aʔ	‘good (focus final)’
/fiʔitatali/	→ ˌfiːʔtaˌtai̯ˈli	∼ ˌfiːʔtaˈtai̯l	‘hibiscus bush (foc.)’

c. **Cayuga Vh → hV** (Foster, 1982): 70)

/kahwistʔaeks/	→ kʰḁwisdʔaes		‘it strikes/chimes’

d. **Andalusian Spanish sC → hC** (Gilbert, 2022; Ruch, 2008)

/kosta/	→ [kohtha]	∼ kotha	‘coast’
/pestaɲa/	→ pehthaɲa	∼ pethaɲa	‘eyelash’

e. **De’kwana Carib wC → Cw** (Hall 1988: 239)

/aːwdaːho/	→ aːwdwaːho	∼ aːdwaːhoɲa	‘garden’
/tadaːwde/	→ tadaːwdwe	∼ tadaːdwe	‘to grate’
/aːʔdewʔke/	→ aːʔdewʔkwe	∼ aːdeʔkwe	‘speech’

In analyses that cast metathesis as transposition, the explanation for the incomplete forms in (85) is not obvious. We could say that these are pronounced gradiently as a kind of paradigm uniformity effect (Steriade, 2000), diachronic residue, or that they are simply speech errors. If they are speech errors, then they are quite regular — they occur in around 10% of all metathesized forms in Andalusian Spanish (Ruch 2008: 78) and Meto (Gilbert and Mooney, 2022). As for the explanation that they are a kind of paradigm uniformity, then there is a problem of overgeneration. In other forms of reordering, such as infixation, there is no reported phonetic incompleteness in any of the many typological studies that exist (Kalin, 2022; Moravcsik, 2008; Ultan, 1975; Yu, 2007, 2003). (I’ll return to this last fact in Section 3.5, where I argue that morphologically-restricted metathesis is never phonetically incomplete.)

Both of these explanations cast the forms in (85) as a surface phonetic effect, but not something that reflects any deep abstract structure. (This makes sense: under a transposition analysis of metathesis, the sounds can either reorder, or not. There is no in-between.)

However, as I will demonstrate, there is evidence that the phonology does treat metathesis-derived sequences differently from ones that are faithful to their underlying precedence structure. Not only are these patterns often phonetically incomplete, they are also opaque to other phonological restrictions. This is the property I termed *invisibility* in Chapter 2 (see also Hall (2003) and Gilbert and Mooney (2022)).

One illustration of invisibility in Meto is its failure to interact with consonant deletion. Ordinarily, Meto word-final consonants delete in phrase-medial positions. This means that CVVC forms like /tais/ 'sarong' are realized as [tai], as in (86a.). However, metathesized forms are immune to this restriction, and so a form like /tasi/ 'sea' will be realized as [ta͡ɪs] in (86b.).

(86) Meto consonant deletion is blind to metathesis

	UR	phrase-medial	gloss	phrase-final
a.	/tais metan/	[ta͡ɪ ˈmetan]	'black sarong'	[ˈtais] 'sarong'
b.	/tasi metan/	[ta͡ɪs ˈmetan]	'black sea'	[ˈtasi] 'sea'

Metathesis is *invisible* because its outcome has no bearing on the application of consonant deletion.

In the typological survey in Section 3.2, I find that this behavior is a universal: no language has general metathesis that is visible to phonology like reduplication, word minimality, or phonologically-conditioned allomorphy. Metathesis is always phonologically invisible.

Another property of metathesis is that it is not structure-preserving (see similar argument for epenthetic consonants in Chapter 5). In Andalusian Spanish, metathesis creates [Ch] sequences despite there being no aspirated stops or other [Ch] sequences. The only time [Ch] can arise is when it is derived from /sC/.

(87) Non-Structure Preservation: Andalusian Spanish /sC/ → [Ch] metathesis

a.	/las̲ tapas/	[la th̲apah]	'the tapas'	*[la tapah]

b. /tapas/ [tapah] 'tapas' *[thapah]

So, forms like [la thapas] are licit, but hypothetical inputs such as /t(h)apas/ mustr neutralize to [tapas].

Constraint-based grammars undergenerate these patterns when they (i) assume Richness of the Base (Prince and Smolensky, 1993, : 209) and (ii) treat metathesis as transposition. I illustrate this problem in (88) using the Andalusian Spanish data. With a Rich Base, both /tapas/ and /thapas/ should be available as inputs. If we rank *Ch ≫ MAX-H, we can derive the correct surface output. However, when we add metathesis cases, a problem arises: we incorrectly derive [la tapas].

(88) Undergeneration of non-structure preserving metathesis in Andalusian Spanish

		*hC	LIN	*Ch	MAX-H
/thapas/	a. thapas			*!	
	☞ b. tapas				*
/tapas/	☞ a. tapas				
	b. thapas			*!	
/lah tapas/	a. lah tapas	*!			
	☹ b. la thapas		*	*!	
	💣 c. la tapas				*

These problems with Richness of the Base are common in metathesis (Section 3.2), but not unique to it. Gouskova (2023) and Mackenzie (2022) independently assert that Richness of the Base induces similar problems in Russian voicing alternations that are not structure preserving. The takeaway is that we need some way of distinguishing structure-preserving and non-structure preserving patterns in OT, whether it be through derivational or representational means.

I argue that these two disparate facts — invisibility and non-structure preservation — can be unified under a single generalization, *Invisibility* (following Gilbert 2022; Gilbert and Mooney 2022). Metathesized sequences are never treated as equivalents of their fully-reordered forms.

(89) **INVISIBILITY OF METATHESIS.** Metathesized sequences in language-general patterns:

(i) are inert with respect to stress assignment, reduplication, word minimality, and allomorphy;

(ii) can be non-structure preserving.

In transposition-based models, *Invisibility* can be captured by using Cophonologies (Anttila, 1997; Inkelas et al., 1996; Orgun, 1996) or Stratal OT (Bermúdez-Otero, 1999, 2003; Kiparsky, 2000). By ordering metathesis late, we can generate these patterns. However, this doesn't explain the gap: there are no languages with "early" metathesis that treat it as a phonetically incomplete pattern. For instance, no language has phonetically incomplete metathesis that is visible to weight-sensitive stress assignment (compare with Andalusian Spanish, Section 3.4.3). I return to this point in when I discuss the typological survey (Section 3.2) and alternatives (Section 3.7).

Later on, I argue that *Invisibility* can be explained quite intuitively: in general patterns, metathesis never reorders segments. Metathesized sequences will therefore always have the behavior expected of their faithful order, not the putative surface one. I return to this claim in Section 3.4, where I illustrate this in more detail for Meto and Andalusian Spanish. For now, I maintain *Invisibility* is an area where previous theories undergenerate.

3.1.3 Interim summary

To summarize, transposition-based theories both overgenerate and undergenerate metathesis. Models that treat metathesis as transposition generally overgenerate vowel-vowel metathesis (e.g. *hypothetical*: /pa-i/ → [pia], *The Vowel-Vowel Problem*) and long-distance metathesis (e.g. *hypothetical*: /tat-r/ → [trat], *The Long-Distance Problem*). Both of these patterns are unattested in language-general patterns (Hume 2004; McCarthy 2000, contra Carpenter 2002), and I discuss putative counterexamples in Section 3.6.3.

Undergeneration is also a problem for these same models. Metathesized sequences are frequently phonetically incomplete, producing sequences that fully overlap the intervening sound (e.g. /pasta/ → [pa<u>htha</u>] 'pasta', Andalusian Spanish, Gilbert 2022: 42). These are unexpected in models with transposition: the sounds should reorder fully or not at all. I also observe that metathesis occurs in what appear to be counter-feeding relationships with other phonology (Meto consonant deletion) and it can produce sequences of sound that are Non-Structure Preserving (Andalusian Spanish [Ch] sequences). From this, I claim that language-general metathesis is *Invisible*: other phonology operates as if the sounds have not reordered.

I first discuss a typological survey, which corroborates these observations. I then discuss the proposal, which I argue resolves the overgeneration and undergeneration problems.

3.2 Typological survey of metathesis

In the previous section, I discussed two gaps in the typology of metathesis: no vowel-vowel metathesis (the *Vowel-Vowel Problem*) and no long-distance metathesis (the *Long-Distance Problem*).[16] These generalizations were largely based off of previous typologies, including Blevins and Garrett (1998); Buckley (2011); Canfield (2016); Carpenter (2002); Edwards (2016); Heinz (2005b); Hume (2001); Hume and Seo (2004); Moskal (2009); Ultan (1971); Webb (1974), and the sizable OSU *Metathesis in Language Archive 2.0*. In this section, I put them to the test against a large, less filtered typological survey of primary sources.

I conducted a typological survey using just under a thousand digitally available grammars from a diverse set of language families. Grammars were searched for the term "metathesis", and then examined by hand. The distribution of grammars is summarized in Table 3.1.

The coarse results in Table 3.1 confirm that metathesis is rare. Only 4.1% (34/838) languages had productive metathesis — here defined quite loosely as having more than three examples in the text. The 48 non-productive metathesis cases often only had it in one or two words. For instance, in Biak (Austronesian, Heuvel 2006: 57) word-final /fk/ sequences may vary with [kf], but only in two words (e.g. [kofk] ∼ [kofk] 'rock', [jofk] ∼ [jokf] 'hide', but [afk] 'bump/plop' *[akf]). If Biak reached the arbitrary three-word cutoff, it would have been counted as a productive (but morphologically-restricted) metathesis pattern.

The 34 productive metathesis patterns were split between being general and morphologically-

[16] Carpenter (2002) offers a counterexample to the *Long-Distance Problem*, but this is spurious. See Section 3.6.3.

	Count	Families surveyed (# grammars)
Grammars surveyed	838	Algic (46), Arawakan (27), Australian (46), Austro-Asiatic (38), Austronesian (164), Bantu (101), Benue-Congo (19), Berber (15), Bora-Witoto (5), Cariban (10), Caucasian (40), Chadic (25), Chibchan (9), Eskimo-Aleut (28), Hokan (17), Iroquoian (19), Khoisan (11), Mande (21), Mongolic (51), Muskogean (14), Na-Dene (33), Nilo Saharan (39), Tai-Kadai (12), Tanoan & Keresan (10), Tungusic (29), Turkic (72), Volta-Niger (19), otherwise unclassified (5)
Non-productive metathesis	49	
Productive metathesis	34	(only 12/34 are not morphologically restricted!)

Table 3.1: Distribution of grammars surveyed for metathesis.

restricted: 12 could be described in terms of sound without exception, and so were listed as language-general; the remaining 18 had clear morphological restrictions, and 4 had not enough data to tell.

To give an example of what I mean by morphological restriction, take metathesis in Ilocano (Rubino 1997: 279). The Ilocano perfective infix ⟨in⟩ generally occurs after the first consonant of the stem (90a.). But, the infix metathesizes when it attaches to a liquid-initial stem (90b.). No metathesis occurs when a prefix intervenes between the infix and a stem-initial liquid (90c.).

(90) Metathesis with morphological restrictions: Ilocano (Rubino, 1997)

a. ⟨in⟩ *generally appears as an infix*

/⟨in⟩-kasao/	k⟨in⟩asao		'PERF.speak.with/'
/⟨in⟩-dakulap/	d⟨in⟩akulap		'PERF.palm'
/⟨in⟩-ʔala/	ʔ⟨in⟩ala		'PERF.get'
/⟨in⟩-gataŋ/	g⟨in⟩ataŋ		'PERF.buy'
/⟨in⟩-mataj/	m⟨in⟩ataj		'PERF.die'

b. ⟨in⟩ *optionally metathesizes to* ni- *in liquid-initial stems*

/⟨in⟩-rugian/	ni-rugian	∼ r⟨in⟩ugian	'PERF-start'
/⟨in⟩-luto/	ni-luto	∼ l⟨in⟩uto	'PERF-cook'
/⟨in⟩-lukatan/	ni-lukatan	∼ l⟨in⟩ukatan	'PERF-open'

c. *No metathesis of* ⟨in⟩ *when prefixes intervene*

/⟨in⟩-i-rugi/	i⟨in⟩-rugi=ko=n		'TRANS-PERF-start'

This pattern is restricted to this one infix. No metathesis occurs in roots (91a.) or with phonologically similar affixes, such as the inchoative infix ⟨um⟩ (91b.) or the 'every' infix ⟨in⟩ (91c.).

(91) Roots and other affixes do not metathesize: Ilocano (Rubino, 1997)

a. *No metathesis in roots*

/talinaed/	talinaed	'remain'
/dulin/	dulin	'keep'
/balin/	balin	'become'
/ʔarinaʔar/	ʔarinaʔar	'moonlight'

b. *No metathesis in inchoative infix* ⟨um⟩

/⟨um⟩-labaga/	l⟨um⟩abaga	'to redden'
/⟨um⟩-raŋaj/	r⟨um⟩aŋaj	'to become progressive'
/⟨um⟩-baket/	b⟨um⟩aket	'to become old ladies'
/⟨um⟩-dakel/	d⟨um⟩akel	'to grow, get big'
/⟨um⟩-karo/	k⟨um⟩aro	'to worsen'

c. *No metathesis of 'every' infix* ⟨in⟩

/⟨in⟩-rabii/	r⟨in⟩abii	'every night'

Ilocano metathesis is thus morphologically restricted, because only the infix <in> undergoes metathesis to [ni-]. I now describe other ways that metathesis can be morphologically restricted before continuing on to discuss Long-Distance and Vowel-Vowel metathesis results.

3.2.1 Four kinds of morphologically-restricted metathesis

Metathesis with morphological restrictions can be grouped into four classes: affixes that metathesize themselves (e.g. Ilocano), affixes that metathesize themselves (infixes), affixes that trigger metathesis on the stem, and stems that metathesize as a way of encoding grammatical information that cannot be predicted from other phonological changes. These are listed in (92) below:

(92) Three kinds of morphologically-restricted patterns

a. **'Affix-on-stem metathesis'**

A particular affix triggers metathesis on the stem (but similar affixes do not).

b. **'Affix self-metathesis / infixation'**

An affix metathesizes when it attaches to certain stems (but not for all stems or similar affixes).

c. **'Affix-stem boundary metathesis'**

A portion of an affix metathesizes across a stem boundary (but not for all stems or similar affixes).

d. **'Stem metathesis'**

The stem metathesizes as a way of representing a grammatical alternation or spontaneous change that cannot be predicted from other phonological factors.

For an example of the affix-on-stem type (92i.), take metathesis in Fur (Jakobi, 1989). Fur metathesis reorders a consonant and vowel, creating a CVCV verb stem, as in (93a.). However, metathesis is phonologically unpredictable, and lexically alternates with mutation (93b.) or deletion (93c.).

(93) Fur: Affix-on-stem metathesis (a.) alternates with mutation (b.) and deletion (c.) (Jakobi, 1989: 64-68)

	Root	3.SG	1.PL	gloss	
a.	/tì/	tì-ò	k-ìt-ò	'strain'	
	/bà/	bà-ò	k-àb-ò	'drink'	
	/nì/	nì-ò	k-ín-ô	'roll up'	
	/lù/	lù-ò	k-ùl-ò	'smear on'	
b.	/ti/	ti-o	k-i-o	'fart'	*k-it-o
	/fu/	fu-o	k-u-o	'blow'	
	/dʒi/	dʒi-o	k-i-o	'lose'	
c.	/bu/	bu-o	k-um-o	'tire'	*k-ub-o
	/fu/	fu-i	k-aw-i	'kill'	
	/du/	du-o	k-an-o	'go'	

The second case, where the affix itself metathesizes (92ii.), is what was found in Ilocano (Rubino, 1997) (see (90) above). The infix ⟨*in*⟩ metathesizes to [ni-] preceding a sonorant. No other affixes in Ilocano metathesize.

The third case is affix-stem boundary metathesis, which is found in Tiberian Hebrew (Coetzee, 1999; Idsardi, 1998; Malone, 1993). In this pattern, the verbal prefix *hit-* triggers metathesis of a sibilant-initial stem, forcing the sibilant rightwards across the morpheme boundary.

(94) Tiberian Hebrew *hitpa'el* reflexive (Malone 1993: 52-53, data from

Coetzee 1999: 106)

	root	transitive (*pi'el*)	reflexive (*hitpa'el*)	gloss
a.	pll	pallel	hit̲pallel	'to pray'
	hlk	hallek	hit̲hallek	'to walk back & forth'
	nbʔ	nabbeʔ	hit̲nabbeʔ	'to prophesy'
	gdl	gaddel	hit̲gaddel	'to magnify oneself'
b.	ʃmr	ʃammer	hiʃt̲ammer	'to protect oneself'
	spx	sappex	hist̲appex	'to feel attached to'
	zdk	zakker	hizd̲akker	'to remind oneself'

No other sibilant-coronal metathesis occurs in the language. (For comparison, Modern Hebrew has the same metathesis pattern (Bat-El, 1988), which is likewise limited to this verbal prefix. In monomorphemic contexts, coronal-sibilant sequences are realized faithfully, e.g. [tsumá] 'input', [tzuzá] 'movement', [tʃuvá] 'answer' (Asherov and Bat-El 2019: 80). Modern Hebrew metathesis has no reported phonetic incompleteness, though this remains to be confirmed in a dedicated acoustic study.)

The fourth case is stem metathesis (92iii.). Here I provide an example from Klallam (Thompson and Thompson, 1971), where the 'actual' form of the verb is derived via metathesis.

(95) Klallam: Stem metathesis to form the 'actual' aspect (Thompson and Thompson 1971, data via Stonham 1990)

	Non-actual	Actual	Gloss
a.	čkʷú-	čukʷ-	'shoot'
b.	xčí-	xíč-	'scratch'
c.	qqií-	qíq-	'restrain'
d.	csə́-	cə́s-	'hit'
e.	ƛkʷé-	ƛə́kʷ-	'grasp'

3.2.2 Long distance metathesis

Long-distance metathesis patterns never occurred in language-general patterns. The only time long-distance patterns appeared was in morphologically-restricted metathesis. An example of this is from Chimariko (Hokan, Jany 2009), where a glottal stop metathesizes past a CV syllable:[17]

(96) Chimariko non-local metathesis: ʔCV → CVʔ (Jany 2009: 42)

	V_	C_
a. /ʔja/ 'again'	[h-išehe-tku-ʔja-t]	[h-imam-jaʔ-t]
	3-lead-DIR-again-ASP	3-see-again-ASP
	'She brought some more (dogs)'	'He sees him again'
	[h-isumta-ʔja-kon]	[h-aʔatok-jaʔ-kon]
	3-look.at-again-FUT	3-return.hither-again-FUT
	'He is going to look at it again'	'He is going to come back'
b. /ʔjew/ 'REFL'	[h-ak^{h}o-ʔjew-taʔn-ta]	[h-ok'im-jeʔw-ta]
	3-kill-REFL-PST-ASP	3-hang-REFL-ASP
	'He has killed himself'	'He has hanged himself'
c. /ʔna/ 'plant'	[mune-ʔna]	[hak'ew-naʔ]
	acorn.of.black.oak-plant	nut.of.sugar.pine-plant
	'Black oak'	'Sugar pine'

In other affixes, the pattern is local. The crucial example is (97a.) — it is suprising that the glottal stop lands after the nasal, rather than before it, cf. (96d.).

(97) Chimariko local metathesis (Jany 2009: 41)

a. /na^{ʔ}či/ 'again'	na^{ʔ}či / C#_	[h-uwu-m-na^{ʔ}či-t]	'All went home'	
	n^{ʔ}ači / V#_	[h-ama-n^{ʔ}ači-t]	'They all ate'	(96c.)
b. /q^{h}ut/ 'in water'	q^{h}ut / C#_	[ʔ-iwin-q^{h}ut-ta]	'I dumped them in water'	
	qtu / V#_	[j-eʔa-qtu-t]	'I get in the water'	

Which pattern occurs is phonologically unpredictable, and must make reference to individual morphemes to get the landing site right.[18]

[17] As an aside, there's a question here of if the glottal stop in Chimariko should be considered a segment, or part of the neighboring (glottalized) consonant. In the latter case, [mune-ʔna] could actually be [mune-nʔa], and so Chimariko would not have long-distance metathesis at all. While this is an open possibility, I contend that Chimariko metathesis is still morphologically restricted and (in Section 3.7.3) phonologically visible.

[18] The pattern is not likely weight-driven because Chimariko stress is on the penult of the stem (Jany 2009: 27). See also Section 3.7.3, which demonstrates Chimariko metathesis is visible to allomorph selection. This provides further evidence that Chimariko metathesis occurs in the metamorph layer.

I therefore revise the generalization about long-distance metathesis to the following:

(98) **THE LONG-DISTANCE GAP**: No language has productive, language-general metathesis of non-local sounds.

Later on in the chapter, I will refine this generalization further. The crucial thing is exactly how we define locality — in segmental or gestural terms. (I'll be arguing for the latter). I discuss this, as well as three putative counterexamples, De'kwana (Cariban,Hall 1988), Lezgian (Caucasian, Haspelmath 1993), and Mutsun (Costanoan, Carpenter 2002), in Section 3.6.

The thing to note here is that the long-distance gap is actually somewhat narrow, since it only applies to general patterns. In comparison, long-distance metathesis is quite common in morphologically-restricted patterns, and also in speech errors ('spoonerisms'), systematic diachronic changes, and dialectal variation (see Section 3.7). This makes the long-distance gap much more remarkable: even in the presence of variation, no fully generalized pattern exists.

3.2.3 Vowel-vowel metathesis

Vowel-vowel metathesis is even more constrained in my survey. While CV and CC metathesis occur as general and morphologically-restricted rules, vowel-vowel metathesis is attested only as a sporadic phenomenon in a few words as a dialectal variant, or in unsystematic diachronic change. Long-distance metathesis, in comparison, is less strigently avoided. While it never occurs as a general rule, it is common in several morphologically-restricted ones.

3.2.4 Survey details

The productive metathesis patterns from the survey are summarized in Table 3.2. I supplemented this set of languages with an additional 17 cases from the literature, shown in Table 3.3.

Additional details on these surveys are discussed at later points. Quality of participating segments is discussed in Section 3.3.3. Examples of morphologically-restricted metathesis are provided in the Appendix.

Family	Language	S1	S2	Morph.-restricted?	Long-dist.?	Source
Algic	Arapaho	ʔ	V	✗	✗	Moss and Cowell 2008: 41
	Atikamekw	m	w	✗	✗	Béland 1978: 300
	Blackfoot	ʔ	V	✗	✗	Frantz 1991: 84, Taylor 1969: 106
	Cheyenne	h	V	unclear	✗	Leman 2011: 223
Arawakan	Axininca Campa	C	j	✓	✗	Payne 1981: 131
	Baré	C	h	✓	✓	Aikhenvald 1995: 7
	Baure	j, h	V	✗	✗	Danielsen 2007: 74-75
Austro-Asiatic	Nicobarese	l, m, n, ŋ, ɲV	ə	✗	✗	Braine 1970: 77
Austronesian	Aklan	h ʔ n	m n g	✓	✗	Chai 1971: 37-38
	Bajau, West Coast	i	n	✓	✗	Miller 2007: 56
	Inonhan	V	r	✓	✗	Goudswaard 2005: 51
	Ilocano	i	n	✓	✗	Rubino 1997: 27, Wimbish 1987: 100
	Nias Selatan	m	h	✓	✗	Brown 2001: 114
	Palauan	m	C	✓	✗	Josephs 1975: 151
	Selaru	w	b	✓	✗	Coward 1990: 89
	Toqabaqita	V	C	✓	✗	Lichtenberk 2008: 378-379
	Tagalog	t, d, l, n	p, b, t, d, m, n	✓	✗	Schachter and Otanes 1972: 380
Cariban	De'kwana	w	d, k	✗	* (3.6)	Hall 1988: 239
	Macushi	ʔ	i, u	✗	✗	Abbott 1992: 148
Caucasian	Lezgian	C	w	✗	* (3.6.3.1)	Haspelmath 1993: 59-60
	Svan	w	C	✓	✗	Tuite 1998: 11
	Udi	d, č, š	s	✓	✗	Schulze 2005: 592-593
Costanoan	Mutsun	C	V	✓	✗	Mason 1916: 405
Hokan	Chimariko	ʔ	CV	✓	✓	Jany 2009: 41
	Tol	high V	C	unclear	✗	Holt 1999: 16

Family	Language	S1	S2	Morph.-restricted?	Long-dist.?	Source
	Washo	m, ŋ, j	ʔ	✗	✗	Jacobsen 1964: 275
Iroquoian	Cherokee	V	h	✗	✗	Montgomery-Anderson 2008: 68
	Mohawk	w	h	unclear	✗	Hopkins 1988: 67
	Tuscarora	w	h	✓	✗	Mithun 1974: 73
Muskogean	Mikasuki	C	V	✓	✗	Boynton 1982: 42
isolate	Kutenai	C	V	unclear	✗	Morgan 1991: 207-210
	Seri	m	h	✗	✗	Marlett in prep: 993
Tungusic	Evenki	k	p, v	✓	✗	Nedjalkov 1997: 321
Turkic	Tuvinian (Tuvan)	p	k, q	✗	✗	Harrison 2000: 16 -17
Languages in survey:		34				
Language families represented:		12 (2 isolates)				

Table 3.2: Grammar survey: Languages with productive metathesis

Family	Language	S1	S2	Morph.-restricted?	Long-distance?	Source
Afro-Asiatic	Sidaama	C	nasal	✓	✗	Gouskova 2004: 226
Austronesian	Kwara'ae	C	V	✗	✗	Heinz 2005b
	Leti (internal)	C	V	✗	✓	van Engelenhoven 2004
	Leti (external)	ɲ	C	✓	✗	Blevins 1999
	Meto	C	V	✗	✗	Mooney 2023
	Rotuman	C	V	✗	✗	Churchward 1940
Costanoan	Sierra Miwok	C	V	✓	✗	Freeland and Voegelin 1951
Indo-European	Andalusian Spanish	h, s	C	✗	✗	Gilbert 2022
	Faroese	s	C	✗	✗	Hume and Seo 2004
	Lithuanian	s	C	✗	✗	Hume and Seo 2004
Caucasian	Georgian	r	v	✓	✗	Butskhrikidze 2002
Iroquoian	Cayuga	V	ʔ	✗	✗	Foster 1982
Mixe-Zoque	Zoque	j	C	✓	✗	Wonderly 1951
Nilo-Saharan	Fur	C	V	✓	✗	Jakobi 1989
Otomanguayan	Nivaĉle	C	V	✗	✗	Gutiérrez 2020
Salishan	Klallam	C	V	✓	✗	Thompson and Thompson 1971
Semitic	Hebrew, Tiberian	s, ʃ, z	t, d	✓	✗	Malone 1993: 52-53
Languages in survey:		16				
Language families represented:		11				

Table 3.3: Languages with metathesis from the literature

To summarize, the typological survey confirmed three facts: (i) that productive, general metathesis is rare, (ii) that no language has general long-distance metathesis, and (iii) that no language has (general or restricted) vowel-vowel metathesis. I now proceed to the analysis, which will derive these facts without running afoul of the same overgeneration and undergeneration issues discussed in Section 3.1.

3.3 Analysis

In this section, I claim that the typology of metathesis is split: Language-genereal metathesis and morphologically-restricted metathesis are not the same.

I claim that language-general metathesis has the following properties:

(99) *Characteristics of language-general metathesis (based off of Hall 2006 on vowel intrusion)*

a. Phonetically incomplete

b. Reduces / compresses existing structure

c. Appears to be the result of gestural overlap / gestural nesting

d. Can produce sounds that are otherwise not found in the language

e. Morpho-phonology (e.g. stress assignment, reduplication, allomorphy) behaves as if only the original order is present

f. Tends to involve sonorants (see Section 3.3.3)

Based on these properties, I argue that language-general metathesis is not transposition at all, but gestural overlap represented as spreading in the timing layer.

In comparison, I claim that morphologically-restricted metathesis looks more like transposition. It can be long-distance under certain circumstances (Section 3.2) and it has none of the reported phonetic incompleteness of language-general patterns (Section 3.1.2).

(100) *Characteristics of morphologically-restricted metathesis*

a. Phonetically complete

b. Does not appear to compress duration or structure

c. Can be driven by arbitrary requirements of individual morphemes

d. May be visible to stress assignment in weight-sensitive languages

To capture this typology, I cast my analysis in Lamination Theory. Lamination Theory proposes that there are two layers of phonological grammar, each with distinct operations. The timing layer uses gestural representations, and cannot transpose. The metamorph layer, on the other hand, is considerably more powerful (resembling unrestricted GEN from standard OT), and is capable of transposition.

In the next section, I argue that language-general metathesis occurs via spreading in the timing layer. I argue that this analysis allows us to capture the absence of long-distance and vowel-vowel metathesis patterns in general terms. I will also demonstrate that this analysis does not undergenerate, and derives phonetic incompleteness and "invisibility" of metathesis with ease (see Section 3.4). In my theory, these facts are related to the idea that segments never reorder.

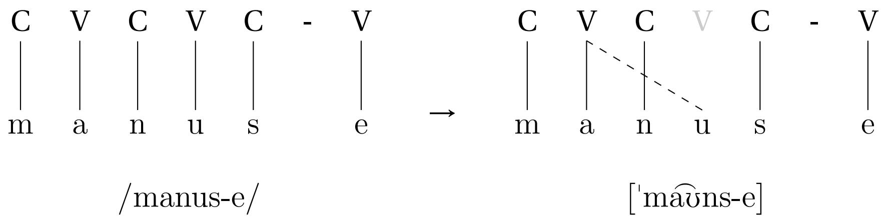
While I will not deal with morph-restricted metathesis in detail, I argue that it must be derived through a different pathway. The typology of morphologically-restricted patterns is distinct from the language general ones: it can be long-distance (Section 3.2) and it doesn't have the same reported phonetic incompleteness (Section 3.1.2). I'll return to this argument in Section 3.5, but for now focus on the language-general case.

3.3.1 Language-general metathesis as spreading

I cast language-general metathesis as a kind of spreading (Archangeli, 1983; Besnier, 1987; McCarthy, 1989; Sohn, 1980). Languages with metathesis have highly-ranked markedness constraints that disprefer certain sequences of slots. To avoid these, these languages associate a single slot with more than one segment. Metathesis is the result of when a single slot associates with two *non-adjacent* segments.

For an example, take an example of metathesis from Meto (Austronesian), where /manus-e/ metathesizes to [ˈma͡ʊns-e] 'the betel vine'. In the input, one-to-one association between segments and slots is penalized due to prosodic markedness constraints (see Section 3.4.1 for details). The output therefore associates a single slot with two segments, [a] and [u], forcing the [u] to compress and extend across the intervening [n].

(101) Metathesis in Meto: the representation



Phonetic duration data supports the analysis in (101). Metathesis-derived diphthongs are significantly shorter than vowel hiatus in Meto (156 ms (±25) vs. 262ms (±47), t=-5.76 *df*=6.98, p≤0.001***, Mooney 2023). Thus, even though diphthongs are still slightly longer than monophthongs (156 ms (±25) vs. 143ms (±19), t=2.35 *df*=44.66, p≤0.05*, Mooney 2023), the difference is not so great that it implies a second V-slot.

In languages with metathesis, two constraints are dominated: *LINECROSS and *MULTIPLE, defined in (102) and (103) below.

(102) *LINECROSS: 'Association lines cannot cross'

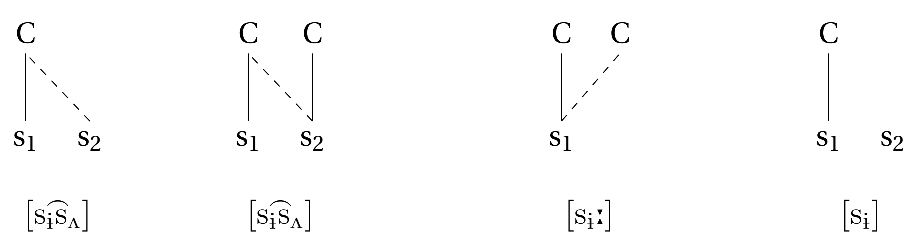
Assign violation for each pair of association lines that cross.

(103) *MULTIPLE: 'Slots are associated with just one segment'

For a slot C/V that is associated with a segment x_i, assign a violation for each segment x_j that is also associated with that slot. (cf. MULT-LINK, Uffmann 2006: 1096)

(104) *MULTIPLE is violated in (a) and (b), but not in (c) or (d) for segments s_1, s_2

a. Shared slots b. Partial shared slots c. Shared features d. Deletion



Violations of *LINECROSS and *MULTIPLE are driven by various markedness constraints, including prosodic alignment (Meto, Section 3.4.1), restrictions on codas (Andalusian Spanish, Section 3.4.3) or consonant clusters more generally (Faroese, Section 3.4.2). What they have in common is that they all concern the number and arrangement of slots. Metathesis is a way of improving slot well-formedness by reducing the slots in the output.

Another way that languages avoid improve sequences of slots is to simply remove them, and leave segments unassociated. This violates the constraint *FLOAT, as in (105):

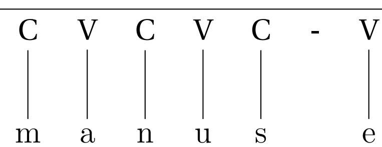
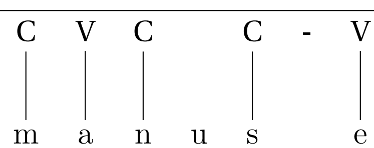
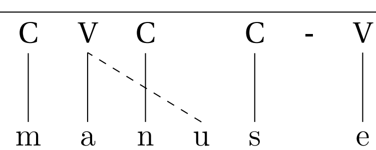
(105) *FLOAT: 'Segments must be associated'

Assign a violation for any segment not associated with a timing slot.

Languages with metathesis have *FLOAT outrank *MULT — they would rather have sounds overlap rather than they not be pronounced at all. Metathesis is thus a way of conserving contrasts in the input (following Ultan 1971) — it's a way of preserving segments that would eitherwise go unpronounced.

I schematize the Meto derivation in (106). (For now, I abstract away from the exact markedness constraint responsible for slot deletion, and just represent it as MARKEDNESS-V_2.) The [u] segment diphthongizes across an intervening segment in the winning candidate (c.) rather than reduce in-situ and violate *FLOAT (candidate b.).

(106) Meto metathesis as *FLOAT ≫ *MULTIPLE, *LINECROSS

/manus-e/	MARK-V_2	*FLOAT	*MULT	*LINECROSS
a. 	*!			
b. 		*!		
☞ c. 			*	*

Since *MULT is dominated in these languages, it's crucial to be able to restrict when it applies. The primary way I do this is with a strong locality restriction on line-crossing, *the Rule of Most Specified*, from Section 2.2.1. (The Rule of Most specified states that association lines can only cross when one segment is specified for more features than another.) This rules out line-crossing of like over like, such as stop-stop metathesis, vowel-vowel metathesis, and so on, but it does not explain why metathesis is so segmentally restricted in languages where it occurs. In the next section, I propose an explanation.

3.3.2 Hierarchies of spreadability

In this section, I explore an extension to *the Rule of Most Specified*. The *Rule of Most Specified* determines which association lines can cross in an absolute sense. I argue that this same feature-counting mechanism is also sensitive to the *degree* of difference between segments. More sonorous segments are not only more likely to be able to spread, but they are judged as better-formed when they do (following Uffmann 2006: 1098).

Recall, the Rule of Most Specified is a restriction on line-crossing for CV skeleta in the timing layer. Association lines can only cross when one segment contains more features than the other. Upon lamination, this equates to a restriction on containment: gestures with more specific targets (in areas of the inventory with denser featural contrasts) can only contain gestures that are simpler.

To illustrate, consider what happens when we adopt a fairly standard feature set, such as one where vowels contain consonant features (Clements, 1991; Clements and Hume, 1995; Halle, 1995) and features like strident, nasal, and laterality may all be underspecified. The Rule of Most Specified generates a cline of spreadibility, shown in (107). Segments on the left hand side are more specified, and thus can spread across more kinds of intervening segments, whereas those on the right are less specified, and will rarely be able to spread across any segments at all.

(107) Expected cline of spreadability from the *Rule of Most Specified*

	More specified, more likely it can spread			*Less specified, less likely it can spread*		
	vowels	≫ glides	≫ sibilants, liquids	≫ nasals	≫ labials	≫ obstruents
# feat.	6+	6	5 or 6	5	4 or 5	4

The hierarchy in (107) is based solely on feature counts, but it closely resembles a sonority hierarchy, which also typically rank vowels ≫ glides ≫ liquids ≫ nasals ≫ obstruents (Bell and Hooper, 1978; Clements, 1990; Jespersen, 1904). The universality of sonority (and its lack of clear acoustic correlates, Parker 2002) has been the matter of intense debate in recent years (Gordon et al., 2012; Henke et al., 2012; Jany et al., 2007; Parker, 2002, 2012), with languages seeming to differ in unpredictable ways on how they rank segments. The *Rule of Most Specified* offers a heuristic for inferring this hierarchy from how contrasts are distributed in a language.

I propose that the same hierarchy in (107) is also responsible for determining how well-formed spreading is in a gradient sense. I reproduce *MULTIPLE below, the constraint that penalizes multiply-associated slots:

(108) *MULTIPLE: 'Slots are associated with just one segment' reproduced from (103)

For a slot C/V that is associated with a segment x_i, assign a violation for each segment x_j that is also associated with that slot. (cf. Uffmann 2006: 1096)

I claim that *MULTIPLE is easier to violate for segments that are more specified.[19] Using the same scale from (107), we then produce the hierarchy in (109) below, but in reverse:

(109) Hierarchy of *MULTIPLE based on feature specificity

*MULT[OBS] ≫ *MULT[LAB] ≫ *MULT[NAS] ≫ *MULT[LIQ], *MULT[STR] ≫ *MULT[GLIDE] ≫ *MULT[VOWEL]

The worst violation is when an obstruent is multiply-linked [tː].

My proposal closely follows previous accounts that only allow complete overlap for more sonorous segments. Uffmann (2006) proposes a markedness-based hierarchy for *MULTIPLE

[19] This hierarchy also applies to *LINECROSS, the constraint that penalizes line-crossing (see Chapter 4). The choice between *LINECROSS and *MULTIPLE hierarchies won't be crucial for any of the cases I discuss in this section, so I use *MULTIPLE for expositional ease.

to capture the typology of consonant epenthesis. Hall (2003) also proposes a family of *C-IN-V constraints, which penalize obstruents contained in vowels more than sonorants contained in vowels (*OBSTRUENT-IN-V ≫ *C-IN-V, Hall 2003: 23-24). Uffmann (2006) also makes a similar proposal with *SKIP (a constraint against not spreading to intervening segments), which penalizes spreading over high-sonority segments more than spreading over low-sonority ones. Walker (1999) also uses a similar hierarchy for spreading in the typology of nasal harmony.

The phenomena these accounts focus on are different, ranging from vowel intrusion, to consonant epenthesis, to nasal harmony, but the generalization remains the same. If a vowel can spread through low-sonority sounds, it often can also spread through higher-sonority ones.

3.3.3 Restrictions on quality for general metathesis

The spreading analysis predicts that sounds that are more specified should be more prone to metathesis, since there are more sounds they can spread over (the Rule of Most Specified). Metathesis of sonorants and sibilants should therefore be fairly common, but stop-stop metathesis should be a gap.

When we examine the typology from Section 3.2, we find these predictions are borne out, as shown in Table 3.4. Labials, laryngeals, glides, vowels, sibilants, and nasals are all well-attested in metathesis patterns, as expected. Evidence for stop-stop metathesis, in comparison, is sparse, with no productive cases found.

To walk through how I derive this, consider the sample consonant inventory in (110) below. Nasals, stridents, rhotics and laterals all bear privative features, and are thus more specified than, say, obstruents like /p t k b d g/. If we assume that these feature specifications are fairly typical insofar as representations of sonorants go, then the constraint hierarchy of *MULT from *the Rule of Most Specified* predicts that sonorants should be more prone to metathesize than obstruents.

Additionally, *the Rule of Most Specified* predicts that obstruent-obstruent metathesis should be quite rare, particularly when between two stops or two (non-strident) fricatives. The intuition here is that these sounds are typically not specified for additional privative features (NAS, STR,

Type of metathesis	Segments involved	# lgs.	Languages (see sources in Table 3.2)
Consonant-Vowel	various consonants and vowels	19	*Bajau (West Coast), Baure, Cayuga, *Fur, *Ilocano, *Inonhan, *Klallam, Kutenai, Kwara'ae, Leti (internal), Macushi, Meto, *Mikasuki, *Mutsun, Nicobarese, Nivaĉle, Rotuman, *Sierra Miwok, *Toqabaqita
	Laryngeal & vowel	5	Arapaho, *Baré, Blackfoot, Cherokee, Cheyenne
Consonant-Consonant			
	Labial & labial	2	Atikamekw, *Selaru
	Labial & laryngeal	4	Mohawk, *Nias Selatan, Seri, *Tuscarora
	Labial & sonorant	1	*Georgian
	Labial & stop	6	De'kwana, *Evenki, Lezgian, *Palauan, *Svan, Tuvinian
	Glide & C	3	*Axininca Campa, Tol, *Zoque
	Laryngeal & stop	1	*Chimariko
	Laryngeal & sonorant	2	*Aklan, Washo
	Sibilant & stop	5	Andalusian Spanish, Faroese, *Hebrew, Lithuanian, *Udi
	Sonorant & obstruent	3	*Leti (external), *Sidaama, *Tagalog
	Total	51	

Table 3.4: Attested segment qualities in general and restricted metathesis patterns. Restricted metathesis is marked with an asterisk.

LAT,, and so on), and so in clusters composed of ordinary obstruents like /p t k b d g/, neither obstruent would be more specified than the other, and so line-crossing is ruled out. Stop-stop metathesis should therefore be impossible.

(110) A sample consonant feature system

	PLACE	VOI	CONS	SON	NAS	CONT	LAT	STR	S.G.	HIGH	ROUND	# feat.
p	LAB	-	+	-	0	-	0	0	0	0	(+)	4
b	LAB	+	+	-	0	-	0	0	0	0	(+)	4
t	COR	-	+	-	0	-	0	0	0	0	0	4
d	COR	+	+	-	0	-	0	0	0	0	0	4
k	DOR	-	+	-	0	-	0	0	0	0	0	4
g	DOR	+	+	-	0	-	0	0	0	0	0	4
f	LAB	-	+	-	0	+	0	(0/+)	0	0	(+)	4
v	LAB	+	+	-	0	+	0	(0/+)	0	0	(+)	4
m	LAB	+	+	+	+	-	0	0	0	0	(+)	5
ŋ	DOR	+	+	+	+	-	0	0	0	0	0	5
n	COR	+	+	+	+	-	0	0	0	0	0	5
r	COR	+	+	+	(0/-)	+	-	0	0	0	0	5
l	COR	+	+	+	(0/-)	+	+	0	0	0	0	5
s	COR	-	+	-	0	+	0	+	(+)	0	0	5
ʔ	LAR	-	+	(+/-)	0	-	0	0	(-)	0	0	3 (or 5)
h	LAR	-	+	(+/-)	0	+	0	0	(+)	0	0	3 (or 5)
j	DOR	+	+	+	(0/-)	+	0	0	0	(+)	0	4 (or 6)
w	DOR, LAB	+	+	+	(0/-)	+	0	0	0	(+)	(+)	4 (or 7)

Languages are expected to differ on how they (under-)specify certain classes of sound, especially glides and laryngeals. For instance, glides in some languages behave like non-syllabic high vowels (e.g. Faroese, Section 5.3.3.1), but in others they behave as sonorant consonants (e.g. Washo, Staroverov 2016). Laryngeals also can either behave similarly to glides (e.g. Nhanda, Blevins and Marmion 1995), or as underspecified voiceless stops (e.g. Burmese [ʔ] coda, Green 2005).

Depending on which features are underspecified, we expect the metathesis possibilities to vary. In languages where glides are like sonorant consonants, sonorant-glide metathesis should be blocked. Similarly, in languages where glides are like vowels, glide-vowel metathesis should be blocked, but glide-consonant metathesis should be possible. The basic prediction from *The Rule of Most Specified* is that metathesis of laryngeals and glides should be well-attested, either as the crossing sound or the sound being crossed over, but that the particulars will depend on how the language organizes its inventory.

I summarize these three generalizations in (111) below. Metathesis should be particularly common among sonorants, variable among glides, and impossible between two like obstruents.

(111) Three generalizations derived by *the Rule of Most Specified*

a. Metathesis of sonorants is likely (across either vowels or consonants)

b. Metathesis of glides and laryngeals is variable. In languages where they act like sonorants, glide-consonant metathesis should be possible.

c. Stop-stop metathesis should be unattested.

An interesting connection can be made here between copy epenthesis and metathesis. If we also analyze copy epenthesis as gestural spreading, then the *Rule of Most Specified* should also be used to determine when vowels can spread over consonants. The prediction is that less-specified consonants should be easier to spread over (and thus more common in the typology), but more specified consonants should be harder to spread over.

In other words, the typology of segments that *block* copy epenthesis should be the same as those that metathesize. In Chapter 4, I argue that this is true: sonorants, sibilants, palatals, and glides are all attested as blockers of copy epenthesis. By contrast, I know of no language where copy epenthesis is only blocked by oral plosives.

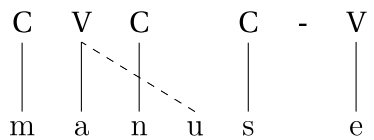
While these predictions are quite general, they also apply well to the analysis of individual languages. In the next section, I'll apply similar reasoning in case studies of general metathesis in Meto, Faroese, and Spanish, where the particular contrasts of the language at hand play a critical role in shaping the availability of metathesis.

3.3.4 Deriving phonetic incompleteness

Language-general metathesis always involves representations with crossed association lines in my analysis. In this section, I briefly review how representations with crossed association lines are laminated into a gestural scores. Based on the principles of lamination (Section 2.3), metathesized sounds are expected to gesturally contain intervening ones, creating incompletely reordered sounds.

To illustrate, let us return to the Meto metathesis example from earlier. The representation of metathesis is shown in (112).

(112) Line-crossing for output of /manus-e/ → [ma͡ʊns-e] ‘the betel nut’, reproduced from (101)

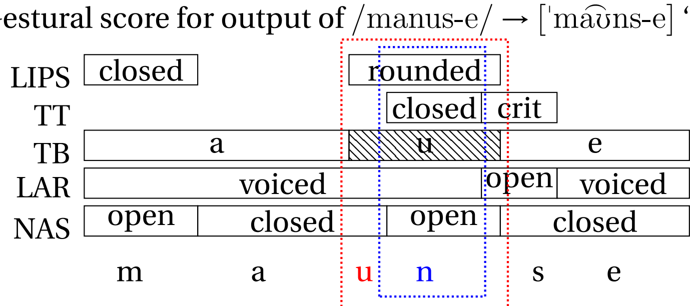


In order to transform this representation into a phonetic output, I claim that languages use an invariant set or principles called lamination (see Section 2.3). One of these principles is the *Law of Order Preservation*, which I reproduce in (113), which concerns the ordering of gestures.

(113) Law of Order Preservation, paraphrased from (34): *If a segment X precedes a segment Y in the input, then the onset of X must occur before the onset of Y* <u>*or*</u> *the offset of Y must occur after the offset of X*

Lamination thus transforms the representation in (112) into the gestural score in (114), where the [u] gesture fully contains the [n].

(114) Gestural score for output of /manus-e/ → [ˈma͡ʊns-e] ‘the betel vine’



We can confirm here that this kind of gestural containment is as required by Order Preservation. The [n] ≺ [u] in (112), and so the [n] offset occurs before the [u] offset in the gestural score. Likewise, the slot associated with [u] from (112) precedes the slot associated with [n], and so the [u] onset precedes the [n] onset. Moving the [u] offset farther left is not an option — if [u] ended before the offset of [n], then the Law of Order Preservation would be violated. Line-crossing thus does not equate to unpronounceability, but creates nested gestures.

This type of gestural nesting derives the exact phonetic incompleteness we observed in Section 3.1.2. In Meto, /manus-e/ can also be realized as [ma͡ʊnu̯s-e] 'the betel nut'. In both cases, the [u] gesture ends after the [n], the only thing that differs is whether the [s] obscures it.[20] This incompleteness is shown in Figure 3.1 (b). Compare this with the phonetically complete metathesis in (a) [ʔa͡ʊs mutiʔ] 'white dog' (cf. [ʔasu] 'dog').

a. Token with complete metathesis b. Token with incomplete metathesis

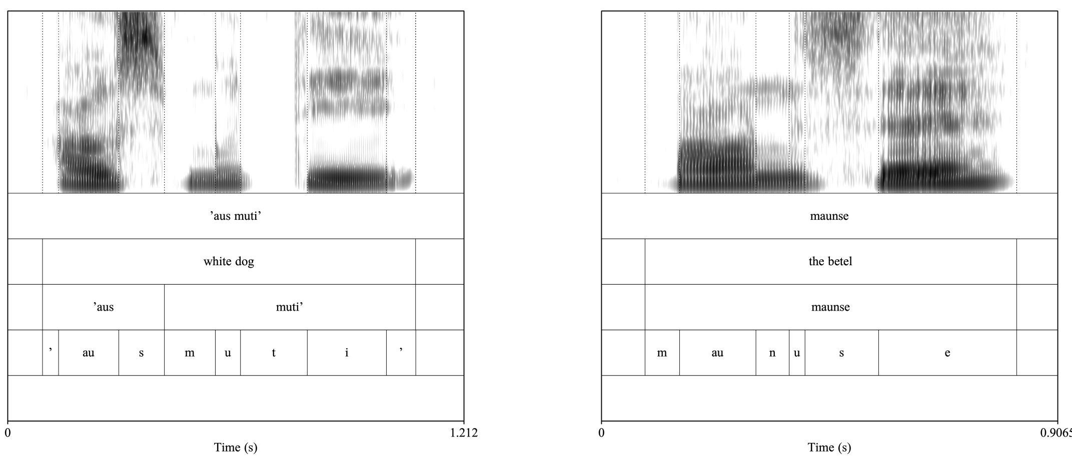


Figure 3.1: Meto metathesis is variable in whether it is (a) complete or (b) incomplete in suffixed forms of /ʔasu/ 'dog' and /manus/ 'betel vine'.

Under this analysis, the output of metathesis is *always* incomplete, but other factors (such as overlapping gestures, or motor planning pressures) will cause the abstract containment structure to be obscured in real-time speech. Metathesis, then, is somewhat of a misnomer in these cases. No segments have reordered. The gesture has shifted leftwards, but its offset remains anchored where it started. Everything else is the same. Later on, this will be important for deriving phonological *Invisibility* — if the segment order is the same, then patterns that reference it will behave as if no reordering has occurred.

[20]Andalusian Spanish presents a more transparent case, where spreading of [h] over C frequently results in containment: /pasta/ → [pahtha] 'pasta'.

Language-general metathesis	Morphologically-restricted metathesis
Overlaps gestures	Transposes segments
Driven by global phonotactics	Driven by arbitrary reqs. of morphemes
Phonetically incomplete (Order Preserving, 2.3.2)	Phonetically complete
Must be gesturally local	Can be long-distance (3.2)
Is a reductive process (other del. & coal. likely)	–

Table 3.5: Two kinds of metathesis under Lamination Theory.

3.3.5 Interim summary

To sum up, I claim that language-general metathesis is a kind of gestural overlap abstractly represented with *spreading*. Spreading, I argue, best allows us to capture the phonetic and locality facts of language-general metathesis. By contrast, I claim that morphologically-restricted metathesis is true transposition. The core differences between these varieties of metathesis are summarized in Table 3.5.

3.4 Language-general metathesis: Case Studies

In this section, I present three case studies on language-general metathesis patterns: Meto (Section 3.4.1), Faroese (Section 3.4.2), and Andalusian Spanish (Section 3.4.3). In each case, I demonstrate that they have three properties in common:

1. **Phonetic incompleteness.** Metathesis is phonetically incomplete and/or shows signs of gestural overlap,

2. **Deletion & spreading.** Metathesis is essentially a reductive process, where the slot-segment relation is no longer one-to-one. Metathesis should therefore share a similar distribution to other non-one-to-one relations for slots and segments, such as deletion (where segments are left floating) and spreading (where segments are associated with more than one slot).

3. **Invisibility.** Metathesis shows signs of *invisibility* (Section 3.1.2), a mismatch between

the metathesized surface order and the order used by the phonology to compute well-formedness.

3.4.1 Meto

Meto is a Southern Malayo-Polynesian language from Eastern Indonesia that has productive, language-general metathesis. The facts and argument I present here closely follow that of Mooney (2023) — I contend that metathesis in this language is gestural overlap, but other details of the analysis differ.[21] The consonant and vowel inventory, along with the assumed feature set, is provided in (115) below. (The column at farthest right marks the number of non-Place features, which will be important later on for the *Rule of Most Specified*.)

(115) Consonant and vowel inventory of Meto, with features

	PLACE	VOI	CONS	SON	NAS	CONT	STR	HIGH	FRONT	ROUND	ATR	# feat.
p	LAB	-	+	-	0	-	0	0	0	0	0	4
b	LAB	+	+	-	0	-	0	0	0	0	0	4
m	LAB	+	+	+	+	-	0	0	0	0	0	4
f	LAB	-	+	-	0	+	0	0	0	0	0	4
t	COR	-	+	-	0	-	0	0	0	0	0	4
n	COR	+	+	+	+	-	0	0	0	0	0	4
l	COR	+	+	+	0	+	0	0	0	0	0	4
s	COR	-	+	-	0	+	+	0	0	0	0	5
ɟ	COR	+	+	-	0	+	0	+	0	0	0	5
k	DOR	-	+	-	0	-	0	0	0	0	0	4
ʔ	LAR	-	+	-	0	-	0	0	0	0	0	4
h	LAR	-	+	-	0	+	0	0	0	0	0	4
i	COR, DOR	+	-	+	0	+	0	+	+	-	+	8
ɪ	COR, DOR	+	-	+	0	+	0	+	+	-	-	8
ɛ	COR, DOR	+	-	+	0	+	0	-	+	-	-	8
o	LAB, DOR	+	-	+	0	+	0	-	-	+	+	8
ɔ	LAB, DOR	+	-	+	0	+	0	-	-	+	-	8
u	LAB, DOR	+	-	+	0	+	0	+	-	+	+	8
a	DOR	+	-	+	0	+	0	0	0	0	0	4

[21] The data I present here comes from my own fieldwork in Bijaepunu, West Timor in the summers of 2018 and 2019.

Metathesis is Meto is extremely robust (Edwards, 2016, 2018; Mooney, 2023; Steinhauer, 1993, 1996). The distribution of metathesis is phonologically predictable, and can be descriptively summarized as three contexts in (116)-(118) below.

(116) *Before vowel-bearing suffixes*

a.	/ˈmanus-es/	→ ˈma͡ʊns-es	'betel-INDEF'	cf. manus
b.	/ʔaˈmepot-in/	→ ʔaˈme͡opt-in	'worker-PL'	ʔaˈmepot
c.	/ˈkokɪs-e/	→ ˈko͡ɪks-e	'bread-DEF'	ˈkokɪs

(117) *In compounds*

a.	/kase-mutiʔ/	→ ka͡es-ˈmutiʔ	'white person (lit. city-white)'
b.	/fafi-ʔanaʔ/	→ fa͡ɪf-ˈʔanaʔ	'piglet (lit. pig-child)'
c.	/neno-tenuʔ/	→ ne͡on-ˈtenuʔ	'Wednesday (lit. day-three)'

(118) *Within phonological phrases*

a.	/manu ˈmutiʔ/	→ ma͡ʊn ˈmutiʔ	'white chicken'
	/ˈmanu/	→ ˈmanu	'chicken'
b.	/au mepo ˈleleʔ/	→ au me͡op ˈleleʔ	'I work the field'
	/ˈleleʔ, au ˈmepo/	→ ˈleleʔ, au ˈmepo	'The field, I work (it).'

I follow Mooney (2023) and analyze Meto metathesis as prosodically conditioned. Stress, which is assigned on the penultimate syllable of the root, also faces a pressure to align with the phonological edge of a phrase. To accomplish this, metathesis *compresses* a phonological phrase, making stress appear closer to the phrase edge without shifting stress itself.

To schematize this process, see (119). In (119a.), an input form like /ˈmanus-es/ has stress on the root's penult, and so two syllables separate stress from the right edge of the phrase. In the output, the number of syllables separating the stress from the right edge is reduced: one syllable has been deleted, and the vowel has metathesized leftwards, coalescing onto the preceding syllable. Similar reasoning follows in (119b.) and (119c.), but with the left edge: metathesis reduces the distance between stress and the edge of the phrase.

(119) Metathesis reduces syllable count to the right or left of primary stress

a.	σ́	σ	σ			σ́	σ		
	má	nu	s-es		→	ma͡un	s-es		‘a betel vine (cf. 116a)’
b.	σ	σ	σ́	σ		σ	σ́	σ	
	ka	se	mú	tiʔ	→	ka͡es	mú	tiʔ	‘white man (cf. 117a)’
c.	σ	σ	σ́	σ		σ	σ́	σ	
	me	po	lé	le	→	me͡op	lé	le	‘work the field (cf. 118a.)’

I argue that Meto metathesis occurs in the timing layer, as it can be fully understood in terms of displacement from changing association and slots. We can model Meto with two sets of rankings: ALIGN(X,R), ALIGN(X,L) ≫ MAX-V, and *FLOAT ≫ *MULTIPLE and *LINECROSS (not shown).[22] These constraints must be in the timing layer, as they are all defined over slots, not segments,. Further deletion does not occur (e.g. *[mans]) because NONFIN ≫ ALIGN(X,R) (not shown below).

(120) ALIGN(X,R): Assign a violation for every V-slot between the stress and the right edge of the phonological phrase.

(121)

/ˈmanus-es/	ALIGN(X,R)	MAX-V	*FLOAT	*MULT
a. C V C V C - V / m á n u s e (all associated)	**!			
b. C V C C - V / m á n u s e (u unassociated)	*	*	*!	
☞c. C V C C - V / m á n u s e (V associated to á and u, crossing C–n)	*	*		*

Note that in the winning candidate (c.), no segments have reordered. Line-crossing gives the appearance of displacement, but the timing layer is Order Preserving — it is incapable of reordering segments.

In forms with no suffixation, such as /ˈmanus/ → [ˈmanus] ‘betel vine’ *[ˈma͡ʊns], metathesis

[22] I assume that stress cannot shift once assigned, as it is assigned in the metamorph layer to the penults of roots. This rules out candidates like [maˈnus-es], where stress has shifted from the root’s penult to the penult of the word.

is blocked by NONFIN ≫ ALIGN(X,R). The stressed syllable is penultimate in the phrase and no reduction occurs.

In compounds, the derivation proceeds similarly, but with ALIGN(X,L). One-to-one association of segments to V-slots is marked, and so the /e/ segment spreads leftwards onto the preceding V-slot.[23] In the winning candidate (c.), *MULTIPLE and *LINECROSS (not shown) are both violated.

(122) ALIGN(X,L): Assign a violation for every V-slot between the stress and the left edge of the phonological phrase.

(123)

/kase-ˈmutiʔ/	ALIGN(X,L)	MAX-V	*FLOAT	*MULT
a. C V C V C V C V C k a s e m ú t i ʔ	**!			
b. C V C C V C V C k a s e m ú t i ʔ	*	*	*!	
☞ c. C V C C V C V C k a s e m ú t i ʔ	*	*		*

The Meto pattern is quite general, and is exceptionless in the language. Metathesis even applies to loanwords, as in (124):

(124) ˈroti ‘bread’ vs. ro͡it ˈmoloʔ ‘yellow bread’

To summarize, Meto metathesis is language-general. It has no morphological restrictions, and its distribution is entirely predictable based on sound. I’ll now demonstrate that Meto also shows signs of phonetic incompleteness (Section 3.4.1.1), it co-occurs with deletion and spreading (Section 3.4.1.2), and is phonologically invisible (Section 3.4.1.3). Together, these three factors support the analysis that Meto metathesis is spreading, not transposition.

[23]Deletion of /a/ of /kase/ does not happen because of initial faith (Beckman, 1998).

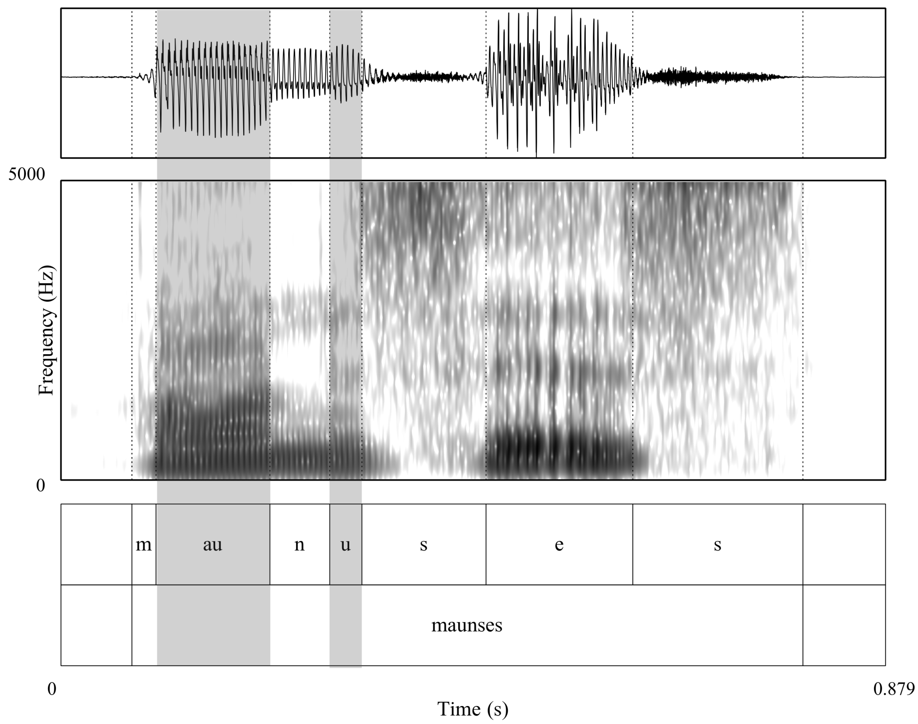


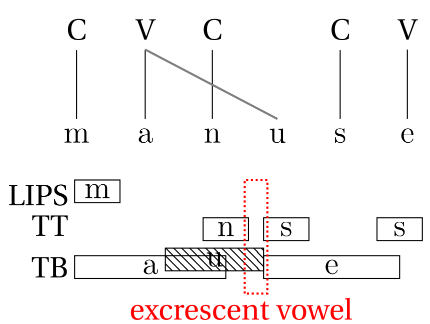
Figure 3.2: Spectrogram of incomplete metathesis /manus-es/ → ma͡ʊnu̯s-es 'a betel vine'

3.4.1.1 Meto: Phonetic incompleteness

Metathesis in Meto is frequently phonetically incomplete, as already described in Section 3.3.4. In around 10% of elicited forms, metathesis surfaces on both sides of the intervening segment. A spectrogram of incomplete metathesis is provided in Figure 3.2.

In Lamination Theory, this is exactly the output we expect. Line-crossing creates nested gestures, so an excrescent vowel should be visible whenever the [n] and [s] gestures pull apart, as in (125) below:

(125)



The fact that these cases exist is therefore evidence in favor of treating metathesis as gestural overlap rather than segmental transposition.

3.4.1.2 Meto: Co-Occurrence with deletion and spreading

Recall, that in this analysis metathesis is a way of reducing surface slot structure. Highly-ranked markedness constraints militate against certain sequences of slots, and so *MULTIPLE is violated so that those slots never need to be produced. This makes two broad predictions. First, that *MULTIPLE may be violated elsewhere the language, creating patterns of gestural overlap that are not metathesis. Second, that these languages may also use other strategies to avoid these marked surface slot structures, such as by deleting slots and leaving segments unassociated.

In this section, I demonstrate that this prediction is borne out: Meto metathesis occurs in complementary distribution with vowel deletion and diphthongization. On one hand, diphthongization is what we expect of *MULTIPLE violations for adjacent vowel segments. Vowel deletion, on the other hand, is another way to avoid certain sequences of slots when multiple-association is independently ruled out.

To illustrate, consider the diphthongization pattern. CVV roots diphthongize to CV͡V in the same general prosodic contexts as metathesis:

(126) CVCV words metathesize in compounds (cf. (117))

a.	/fafi-ʔanaʔ/	→ fa͡if-ˈʔanaʔ	‘piglet (lit. pig-child)’	
b.	/neno-tenuʔ/	→ ne͡on-ˈtenuʔ	‘Wednesday (lit. day-three)’	

(127) CVV words diphthongize in compounds

a.	/meo-ʔanaʔ/	→ me͡o-ˈʔanaʔ	‘kitten (lit. cat-child)’	cf. me.o
b.	/noe-mutiʔ/	→ no͡e-ˈmutiʔ	‘Silver River (town)’	no.e

In my analysis, this is expected. As we will see, diphthongization incurs the same *MULTIPLE violations as metathesis, but does not violate *LINECROSS:

(128)

/meo-ˈʔanaʔ/	ALIGN(X,L)	*FLOAT	*MULT	*LINECROSS
a. C V V C V C V C / m e o ʔ á n a ʔ	**!			
b. C V C V C V C / m e o ʔ á n a ʔ	*	*!		
☞ c. C V C V C V C / m e o ʔ á n a ʔ	*		*	

The present analysis thus gives us an analysis of diphthongization entirely for free.

Meto also has vowel deletion in roots of the shape CVCaC. Recall, CVCVC words metathesize with suffixes (as reproduced in (129) below). But when the second vowel is /a/, as in (130), the vowel deletes instead of coalescing leftwards.[24]

(129) Meto: Vowel-bearing suffixes induce CV → VC metathesis (cf. (117))

a. /ˈmanus-es/ → ˈma͡ʊns-es ‘betel-INDEF’ cf. manus

b. /ʔaˈmepot-in/ → ʔaˈme͡opt-in ‘worker-PL’ ʔaˈmepot

c. /ˈkokɪs-e/ → ˈko͡ɪks-e ‘bread-DEF’ ˈkokɪs

(130) Meto: vowel deletion occurs in CVCa(C) roots

a. /ˈkibaʔ-e/ → ˈkibʔ-e ‘ant-DEF’ cf. ˈkibaʔ

b. /ˈʔu.lan-e/ → ˈʔuln-e ‘rain-DEF’ ˈʔu.lan

c. /ˈpenaʔ-e/ → ˈpenʔ-e ‘corn-DEF’ ˈpenaʔ

We know that this can’t be assimilation of the low vowel (although see Amarasi, Edwards (2016) for an alternate argument), because rising sonority diphthongs are licit elsewhere, as seen in (131):

(131) Meto: Rising-sonority diphthongs are licit elsewhere

[24] In compounds and phrasal contexts, we also see deletion in these same CVCaC roots.

a. /ˈnoah-e/ → ˈno͡ah-e ‘coconut-DEF’ cf. ˈno.ah

b. /ˈpuah-e/ → ˈpu͡ah-e ‘areca.nut-DEF’ ˈpu.ah

What I argue is happening here is a conflict from *Rule of most specified.* I claim that the vowel [a] in Meto is underspecified: it contains no specifications for the three vowel features ([±HIGH, ±ATR, ±ROUND], it only has the features [-CONS, +VOI, +SON, +CONT] (see feature chart in (115), Section 3.4.1). The vowel [a] contains four features, and other consonants in the language contain four or more. The [a] cannot spread over the consonant because they have the same number of features (the Rule of Most Specified). The derivation is thus forced to select the candidate with floating features (132c.), even though it is more marked. For now, I visually represent this as a cover constraint *CROSS[A], as in (132), though I do not predict it can ever be dominated without changing the feature specifications of the language.

(132)

/ˈkibaʔ-e/	*CROSS[A]	ALIGN(X,R)	*FLOAT	*MULT
a. C V C V C – V / k i b a ʔ e (each segment linked to its own slot)		**!		
☞ b. C V C C – V / k i b a ʔ e (a floating, unlinked)		*	*	
c. C V C C – V / k i b a ʔ e (a linked to the V slot of i by a dashed line crossing the line of b)	*!	*		*

Again, we have seen that the very same machinery we needed for metathesis already generates both diphthongization and vowel deletion in Meto. If we analyzed metathesis in terms of transposition, the fact that these three patterns occur in complementary distribution would require a separate explanation.

In Lamination Theory, what these patterns have in common is that they both occur in the timing layer, and so make use of similar base operations — removal of a slot and association. Metathesis must involvee dominated *LINECROSS and *MULTIPLE, and so other violations of

*MULTIPLE are expected to be possible. Reordering segments or deleting them entirely is not possible in timing GEN. Timing GEN can only manipulate timing, not segmental content.

I now turn to invisibility, which I argue supports the hypothesis that Meto metathesis does not involve abstract reordering of segments.

3.4.1.3 Meto: Invisibility

Recall that by *Invisibility* I mean a set of two facts: first, that that metathesis can create non-structure preserving patterns, and second, that metathesized sequences tend to have a mismatch between what their surface order is and the order implicitly used by other phonological patterns. I'll now go through one such case in detail for Meto, and demonstrate how transposition-based alternatives fail to derive this behavior without significant additional machinery.

In Meto, word-final consonants delete when they occur before the primary stress of the phonological phrase. So CVVC words like /tais/ 'sarong' become [ta͡is], as in (133):

(133) Meto: Word-final consonants delete pretonically

a. /tai-s metan/	→ ta͡i ˈmetan	'black sarong'	cf. ˈtai-s	'sarong'
b. /loi-t mate/	→ lo͡i ˈmate	'green money'	ˈloi-t	'money'
c. /fof leko/	→ fo ˈleko	'good smell'	ˈfof	'smell'
d. /hun mate/	→ hu ˈmate	'green grass'	ˈhun	'grass'
e. /snaen mutiʔ/	→ sna͡e ˈmutiʔ	'white sand'	ˈsnaen	'sand'

However, when we consider CVCV words, we find that the exact same context *produces* a CVVC form. So a form like /tasi/ 'sea' metathesizes to [ta͡is], as seen in (134):

(134) Word-final consonants from metathesis do <u>not</u> delete

a. /tasi metan/	→ ta͡is ˈmetan	'black sea'	*ta͡i ˈmetan
b. /manu mutiʔ/	→ ma͡ʊn ˈmutiʔ	'white chicken'	*ma͡ʊ ˈmutiʔ
c. /kolo-ʔane/	→ kol-ˈʔane	'finch'	*ko-ˈʔane

d. /kokɪs moloʔ/ → ko͡ɪk ˈmoloʔ ‘yellow bread’ *ko͡ɪ ˈmoloʔ

My analysis captures this difference quite simply: only word-final consonants delete, and despite appearances, the metathesized consonants in (134) are not word-final.

(135)

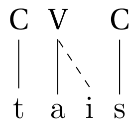
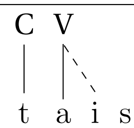
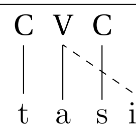
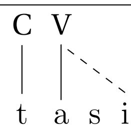
a. CVVC word: Word-final consonant deletes b. CVCV word: No final consonant to delete

For the time being, I account for this pattern using a cover constraint against unstressed consonant-final words, *UNSTR-FINALC defined in (136). Forms with word-final consonants are ruled out (137a.) in favor of deletion (137b.), but metathesized forms are not consonant final and thus have no reason to delete (137d.). Stress cannot be added here to avoid the *UNSTR-FINALC violation, because I analyze Meto stress assignment as a metamorph layer effect: Stress always falls on the penultimate vowel of the root, and these constraints must dominate all timing layer ones by the Blindness Condition (Section 2.5.1).

(136) *UNSTR-FINALC: Assign a violation a word that does not bear stress but has a word-final [+CONS] segment.

(137) Word final consonants unassociate (a.) but surface-final consonants derived from

metathesis do not (b.)

		UNSTR-FINALC	*FLOAT
/tais/	a. 	*!	
	☞ b. 		*
/tasi/	☞ c. 		
	d. 		*!

While the pattern is simple, it presents a thorny problem for OT accounts that use transposition. The problem is this: if metathesis fully reorders segments, then why don't metathesized CVVC words have the same surface behavior as faithful CVVC words? In a model where LIN (or any adjacency constraint) is ranked low, then precedence in the input is not important to preserve — it will be higher-ranked markedness that determines the output. Yet, if this is the case, then the surface outputs of CVVC and CVCV words should be the same because they only differ in precedence.

Concretely, if we assume segments fully reorder (contrary to my analysis), the consonant deletion pattern leads to a ranking paradox. For instance, we know that *UNSTR-FINALC outranks MAX-C (or *FLOAT) because we see consonant deletion in /tais ˈmetan/ 'black sarong':

(138) *UNSTR-FINALC ≫ MAX-C to derive cosnonant deletion ✗

/tais ˈmetan/	*UNSTR-FINALC	MAX-C	ALIGN(X,L)	LIN
☞a. ta͡is ˈmetan	*!		*	
b. tai ˈmetan		*	*	

But, when we apply this ranking to /tasi ˈmetan/ 'black sea', then we incorrectly block metathesis, as in (139). The desired candidate (b.) loses to the candidate with blocked metathesis (a.).

(139) *UNSTR-FINALC ≫ MAX-C to derive cosnonant deletion ✗

/tasi ˈmetan/	*UNSTR-FINALC	MAX-C	ALIGN(X,L)	LIN
💣 a. tasi ˈmetan			**	
☹ b. tais ˈmetan	*!		*	*
c. tai ˈmetan		*!	*	

Reranking does not solve the problem (shown in (140) below). One either fails to derive metathesis, over-derives deletion, or fails to delete altogether. Again, the desired metathesis candidate (b.) loses to the deletion candidate (c.).

(140) ALIGN(X,L) ≫ *UNSTR-FINALC: Metathesis is visible to deletion ✗

/tasi ˈmetan/	ALIGN(X,L)	*UNSTR-FINALC	MAX-C	LIN
a. tasi ˈmetan	**!			
☹ b. tais ˈmetan	*	*!	*	
💣 c. tai ˈmetan	*			*

The problem here is one of counter-feeding opacity (Kiparsky, 1973). In rule-based theories, these kinds of interactions were largely accounted for with rule ordering (Kiparsky, 1973; Rubach, 1984). Subsequent work in OT accomplished similar facts with local conjunction (Bakovic, 2000; Kirchner, 1996), output-output correspondence (Benua, 1997), Stratal OT (Bermúdez-Otero, 1999, 2003; Kiparsky, 2000), sympathy theory (McCarthy, 1999, 2003c), turbidity (Goldrick and Smolensky, 1999; Goldrick, 2000), chain shifts (Łubowicz, 2003), or comparative markedness (McCarthy, 2003a).

While all of these approaches could be applied to the Meto pattern above, they all assert that counter-feeding opacity is a consequence of derivation rather than representation. In the typology of reordering, I believe this misses an important generalization: counter-feeding opacity often involves phonetically gradient patterns. In Lamination Theory, the connection between these effects and gradience is expected from their representational status (Section 2.4.1).

However, in these derivational alternatives, we would be forced to assert that gradience results from the specific derivational mechanism.

The remaining question is thus empirical: are all cases of counterfeeding opacity also phonetically gradient? Lamination Theory claims that they should be, since both opacity and gradience stems from mismatches between timing and metamorph layers. Derivational alternatives, by comparison, may also suffice depending on how the typology of phonetic gradience turns out.

3.4.1.4 Meto: Summary of the analysis

To sum up, in this section I provided an analysis of metathesis in Meto as gestural overlap rather than transposition. The constraint ranking is summarized in (141).

(141) Ranking for Meto metathesis

NONFIN
|
ALIGN(X,R)
|
ALIGN(X,L)
|
*FLOAT
|
*MULTIPLE, *LINECROSS

Empirically, Meto metathesis was found to bear three characteristics: (i) it is phonetically incomplete, (ii) it is in complementary distribution with deletion and spreading, and (iii) it is invisible, meaning that other phonology is blind to the fact that metathesis has occurred. All three of these facts are not only compatible with my analysis, but expected.

I now proceed on to Faroese metathesis. Like Meto, Faroese metathesis is phonetically incomplete and occurs in complementary distribution with deletion. No data on invisibility is available at this time.

3.4.2 Faroese

In Faroese, /sk/ clusters metathesize to [ks] between a stressed vowel and word-final /t/ (Hume and Seo, 2004), as shown in (142). Whether or not Faroese is a general or morphologically-restricted pattern is borderline — metathesis occurs in all skt# clusters, but these only arise with three suffixes: the feminine singular /-t/, the past participle /-t/, and the neuter singular /-t/. There are no exceptions. There is no perfect heuristic for determining how to handle these cases, and so for the purposes of this thesis, I treat exceptionless metathesis like Faroese as a general pattern.

(142) Faroese metathesis sk → ks (Hume and Seo 2004: 38)

a.	/násk-t/	→ náks-t	'impertinent-FEM.SG'
	/báisk-t/	→ báiks-t	'bitter-FEM.SG'
b.	/ínsk-t/	→ íŋ̊ks-t	'wish-PST.PTCP'
c.	/tʊ́sk-t/	→ tʊ́ks-t	'German-NEUT.SG'
	/fráŋsk-t/	→ fráŋ̊ks-t	'French-NEUT.SG'

I assume that what is happening in Faroese is that the [s] gesture extends through the [k], so phonologically, [s] still precedes [k], even though the percept is metathesis. I provide the Faroese consonant inventory with the features I assume in (143) below. The right-hand column summarizes the overall number of non-place features. Coronal consonants are the most specified, since they can bear strident and distal features.[25]

(143) Faroese consonant inventory (based off of Lockwood 1955: 7)

[25] Lockwood (1955) also treats /ʂ̥/ as a phoneme of Faroese. I treat [ʂ̥] as an /rs/ cluster than has undergone coalescence.

	PLACE	S.G.	CONS	SON	NAS	CONT	LAT	STR	DIST	HIGH	# feat.
p	LAB	+	+	-	0	-	0	0	0	0	4
b	LAB	-	+	-	0	-	0	0	0	0	4
t	COR	+	+	-	0	-	0	0	0	0	4
d	COR	-	+	-	0	-	0	0	0	0	4
f	LAB	+	+	-	0	+	0	0	0	0	4
v	LAB	-	+	-	0	+	0	0	0	0	4
k	DOR	+	+	-	0	-	0	0	0	0	4
h	LAR	+	+	-	0	+	0	0	0	0	4
j	DOR	-	+	+	0	+	0	0	0	+	5
m	LAB	-	+	+	+	-	0	0	0	0	5
n	COR	-	+	+	+	-	0	0	0	0	5
ɲ	COR	-	+	+	+	-	0	0	+	0	6
ŋ	DOR	-	+	+	+	-	0	0	0	0	5
r	COR	-	+	+	0	+	0	0	0	0	4
l	COR	-	+	+	0	+	+	0	0	0	5
ʎ	COR	-	+	+	0	+	+	0	+	0	6
s	COR	+	+	-	0	+	0	+	0	0	5
ʃ	COR	+	+	-	0	+	0	+	+	0	6
tʃ	COR	+	+	-	0	-	0	+	+	0	6
dʒ	COR	-	+	-	0	-	0	+	+	0	6

I claim that Faroese metathesis occurs to improve syllable structure. Faroese avoids sequences of consonants that do not overlap, and so metathesis is a kind of covert coalescence that transforms consonant sequences into (heavily overlapping) complex segments.

The constraint I define is a version of *COMPLEX in (144), which is violated for multiple adjacent C-slots.

(144) *COMPLEX: 'No consonant clusters'

Assign a violation for any C-slot not followed by a V-slot.

This definition of *COMPLEX produces slightly different results than its segment-defined counterpart. As a timing layer constraint, speakers will avoid violations of it by manipulating slot structure. In this case, by coalescing multiple segments onto a single C-slot. I argue that complex codas in metathesis and complex onsets in Faroese share a C-slot wherever possible, which (when combined with a place restriction on slot sharing) will correctly limit the set of acceptable onset clusters in the language.

Metathesis is thus expected to be a kind of reductive coalescence, where *MULTIPLE and *LINECROSS are violated instead of *COMPLEX. In stressed syllables, multiple segments associate with one slot (*COMPLEX ≫ *MULT) rather than leave them unpronounced and floating.

(145) *MULTIPLE: 'Slots are associated with just one segment'

For a slot C/V that is associated with a segment x_i, assign a violation for each segment x_j that is also associated with that slot.

(146) *LINECROSS: 'Association lines should not cross'

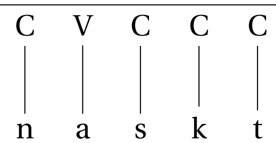
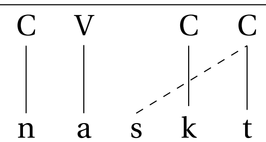
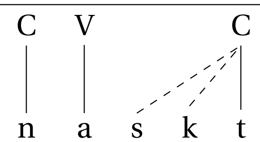
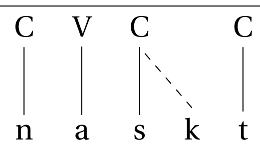
Assign a violation for each pair of association lines that cross.

This is illustrated in the derivation for /naskt/ → [nakst] 'impertinent-FEM.SG' in (148) below. Consonant slots delete to improve violations of *COMPLEX, and the disassociated segments are forced to spread. I also assume that Faroese does not allow obstruents with more than one place ($\text{ONEPLACE}_{\text{OBS}}$), and so spreading landing sites are limited. The two coronals will thus coalesce onto the same slot as in (148b.). Candidates where dissimilar obstruents coalesce are ruled out (148c.-d.)

(147) $\text{ONEPLACE}_{\text{OBS}}$: 'Obstruents have just one place'

For a C-slot associated with at least one [-SON] segment, then the [-SON] segment must bear the same PLACE.

(148)

/naskt/	ONEPLACE$_{OBS}$	*COMPLEX	*MULT	*LINECROSS
a.  [naskt]		**!		
☞ b.  [nakst]		*	*	*
c.  [naskt]	*!		**	
d.  [naskt]	*!	*	*	

Note here that spreading of [t] across [k] is independently ruled out — this would cause a conflict under the *Rule of most specified* (Section 2.2.1) — neither is more specified than the other, and so neither can cross over the other.

Floating segments are not licit within stressed syllables in Faroese, and so spreading is required in the derivation in (142) above. I define the constraint (149), which penalizes floating segments in stressed syllables.

(149) *STR-FLOAT: 'Don't have unassociated segments in stressed syllables'

Assign a violation for a segment not associated with any slot that is in the stressed syllable.

In monosyllables like /naskt/, *STR-FLOAT requires segments to spread (150a. [nakst]) rather than allowing them to float (150b.-c. *[nat], *[nast]).

(150)

/naskt/	*STR-FLOAT	*COMPLEX	*MULT	*LINECROSS
☞ a. C V C C / n a s k t [nakst]		*	*	*
b. C V C / n a s k t [nat]	**!			
c. C V C / n a s k t [nast]	*!		*	

I'll return to what happens in unstressed syllables later on in Section 3.4.2.2.[26]

To sum up, Faroese metathesis is a kind of displacement of gestures, not of segments. The [s] drifts rightwards (represented as spreading in the timing layer), and overlaps with the [t]. The timing layer thus allows displacement, but only to a certain extent — segmental order is preserved by timing GEN.

We now have the basics of an analysis. Faroese metathesis occurs via spreading, but of consonants over consonants. I'll now show that this pattern is also phonetically incomplete and in complementary distribution with deletion, just like we saw in Meto.

3.4.2.1 Faroese: Phonetic incompleteness

When Faroese metathesis occurs after a sonorant, the sonorant devoices, as in (151). In this section I discuss this devoicing as a potential form of gestural overlap.

[26] Spoiler: segments "delete" by remaining floating.

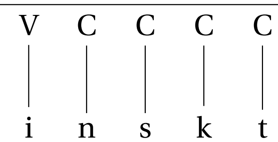
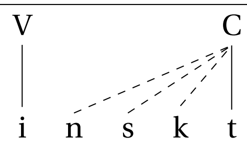
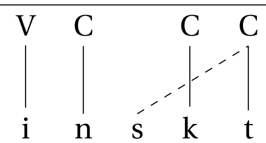
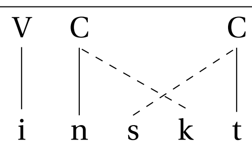
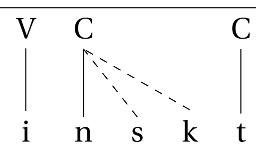
(151) Faroese sonorants devoice with metathesis (Hume and Seo 2004: 38), from (142)

a. /ínsk-t/ → íŋ̥ks-t ‘wish-PST.PTCP’

b. /fráŋsk-t/ → fráŋ̥ks-t ‘French-NEUT.SG’

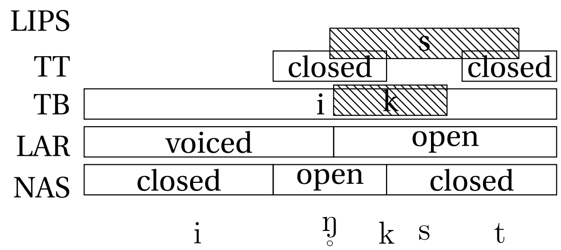
My analysis already derives this. Consider the derivation for /inskt/ → [iŋ̥kst] ‘wish-PST.PTCP’ given in (152). The [s] spreads rightwards as before, but here the [k] also spreads leftwards onto the [n]. (This does not run afoul of ONEPLACE$_{OBS}$, because nasals have no such ONEPLACE restriction. They are free to overlap with consonants of other places, which intuitively I connect to their cross-linguistic tendency to assimilate.)

(152)

/inskt/	ONEPLACE$_{OBS}$	*COMPLEX	*MULT	*LINECROSS
a.  [inskt]		***!		
b.  [inskt]	*!		***	
c.  [inskt]		**!	*	*
☞ d.  [iŋkst]		*	**	*
e.  [inskt]	*!	*	**	

In gestural score, the output from (152d.) is realized as the [s] gesture containing the [k] gesture, shown in (153) below.[27] Higher speech rates produce a pressure for [n] and [k] gestures to be in-phase, causing the [k] to shift leftwards. This triggers assimilation and devoicing of the nasal.

(153) Gestural overlap in /inskt/ → [iŋ̊kst] 'wish-PST.PTCP' responsible for nasal devoicing



According to the gestural score above, what is transcribed as a velar nasal is actually a contour of a coronal followed by a velar — the place assimilation here is partial. Articulatory data should therefore show that the velum moves later in cases with metathesis than in other [ŋC] contexts. The nasal devoicing cases are not as transparently incomplete as the Meto case, but this is to be expected for metathesis of oral consonants. If closure is more narrow, and the distances smaller, then we expect for intermediate forms to be harder to both produce and perceive.

Acoustic studies on Faroese have yet to be performed, and so much of this remains an open question. My prediction is that there should be further cues of incompleteness, such as formant trajectories, the degree and timing of devoicing, and noise from the [s] constriction. These differences may be small, but they should be produced.

Before I continue, it's worth noting that my analysis predicts that preaspiration could occur in other contexts in Faroese. For instance, whenever *COMPLEX can be improved by spreading a voiceless obstruent, we should see preaspiration as a reflex of that spreading.

This appears to be right: preaspiration occurs quite frequently in Faroese (Helgason, 2003; Voeltzel, 2022), including before any sonorant-obstruent sequence.

(154) Faroese preaspiration when a voiceless obstruent is followed by a sonorant (Árnason

[27] We can confirm that this is compatible with the *Rule of most specified*. The [S] is specified for [STR], but [k] is not, and so [s] is more specified than [k]. When the association lines cross, as they do here, then the [s] must contain [k].

2011: 155)

opna	ˈɔʰpna	'open.INF'
rytma	ˈɹɪʰtma	'rhythm.NOM.SG'
betri	ˈbeːʰtri	'better.NOM.M.SG'

Preaspiration also occurs in a number of other contexts as well, such as before voiceless geminates, or before mid vowels that are followed by a voiceless obstruent (Árnason 2011: 155).

The presence of preaspiration in these different contexts may seem as if it should weaken the interpretation that preaspiration is a reflex of metathesis. After all, it does occur whether or not metathesis is present. There is another way to view this as well — Faroese already has the gestural sloppiness expected of languages with metathesis. In future studies, it should be possible to determine if metathesis and preaspiration are connected, as I suggest. For instance, if the degree or duration of preaspiration is different preceding /s/ vs. preceding /k/, we would expect for the metathesized sequences to have preaspiration like /s/, since that gesture contains the others.

For now, I conclude that Faroese facts are consistent with phonetic incompleteness.

3.4.2.2 Faroese: Co-Occurrence with deletion

Under my analysis, metathesis results from segments sharing slots with each other, inducing violations of *MULTIPLE. Metathesis is thus a way of reducing surface slots, much like deletion. In this section, I briefly review some cases of overt deletion in contexts similar to metathesis. I argue that this provides additional evidence of my analysis, because we are seeing transparent evidence of slot reduction.

In unstressed syllables, Faroese /skt#/ clusters undergo deletion, as shown in (155).

(155) Faroese /sk-t#/ delete /k/ if preceding vowel is not stressed (Hume and Seo 2004: 39)

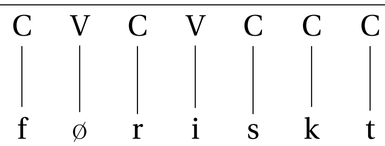
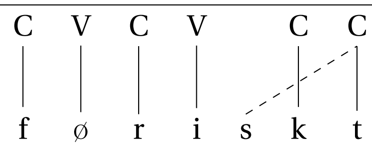
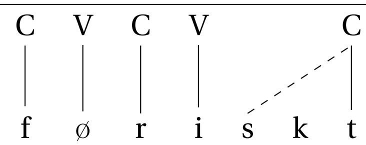
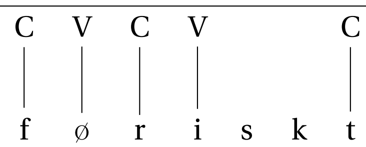
a.	/føˊrisk-t/	→ føˊris-t	'Faroese-NEUT.SG'	*førikst
b.	/rʊˊsisk-t/	→ rʊˊsis-t	'Russian-NEUT.SG'	*rʊsikst

I analyze these cases as deletion of a timing slot alone, without spreading. Recall, Faroese doesn't like floating segments in stressed syllables (*STR-FLOAT). In unstressed syllables, I argue that it's a different story: *FLOAT in (156) is dominated. This means we derive /føriskt/ → [førist] 'Faroese-NEUT.SG', as in (157).

(156) *FLOAT: 'Segments must be associated'

Assign a violation for any segment not associated with a timing slot.

(157)

/føriskt/	*COMPLEX	*FLOAT	*MULT	*LINECROSS
a. 	**!			
b. 	*!		*	*
☞ c. 		*	**	
d. 		**!	**	

When we combine this ranking with what we saw of ONEPLACE$_{\text{OBS}}$ before, this analysis makes a strong prediction: Faroese should only allow unstressed syllables to contain obstruent-obstruent codas when they match in PLACE.

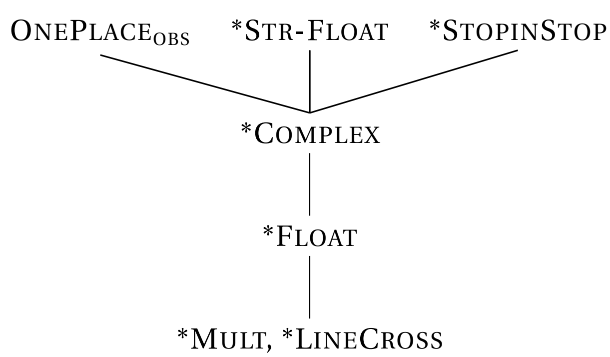
To my knowledge, this prediction is true: Heterorganic obstruent codas only occur in stressed syllables in Faroese. Faroese has initial stress, and so we expect heterorganic obstruent codas in initial syllables, but not elsewhere. Compounds pose an apparent exception to this (e.g. [ˈplɔaːˌ.loft] 'blue sky', Árnason 2011: 158), but they have independently been argued to bear secondary stress on the second syllable (Lockwood 1955: 8). If true, then [ˈplɔaːˌ.loft] 'blue sky' is not a counterexample, because secondary stress permits the complex coda through *STR-FLOAT (following the same derivation as [nakst] from (150).

There are more cases to discuss in Faroese,[28] but for now I'll stop here. The generalization should be clear: Faroese metathesis, like Meto, occurs in complementary distribution with deletion. My analysis thus makes predictions not just for gestural containment in metathesis, but also for a high degree of gestural overlap in certain consonant-consonant clusters. I leave this to be tested in future work.

3.4.2.3 Faroese: Summary of the analysis

To summarize, here I argued that Faroese metathesis is a kind of gestural overlap, formalized as spreading. The constraint ranking is given in (158) below:

(158) Constraint ranking for Faroese



I argued that Faroese metathesis is quite similar to Meto, showing (i) phonetic incompleteness (sonorant devoicing), and (ii) co-occurrence with deletion. The fact that these characteristics arise together is no accident in my analysis, but a consequence of how gestural overlap is formalized. Both Meto and Faroese metathesis are timing-layer effects, and therefore will *lack* characteristics expected of segmental alternations in the metamorph layer. Gestural timing is all that has been changed here; segmental order is respected.

In the next section, I show that we have the same constellation of characteristics in yet another language, Andalusian Spanish. Based on Gilbert (2022), metathesis in this language is phonetically incomplete, it co-occurs with deletion, and it is phonologically invisible.

[28] Such as deletion before liquids, e.g. /fálsk-t/ → fáls-t 'false-NEUT.SG', (Hume and Seo, 2004).

3.4.3 Andalusian Spanish

In Andalusian Spanish, coda /s/ debuccalizes and metathesizes with a following voiceless obstruent (Gilbert, 2022; Parrell, 2012; Ruch, 2008). I first summarize the consonant inventory of Spanish in (159):

(159) Castilian Spanish consonant inventory (Martínez-Celdrán et al., 2003)

	PLACE	VOI	CONS	SON	NAS	CONT	LAT	STR	DIST	HIGH	# feat.
p	LAB	-	+	-	0	-	0	0	0	0	4
b	LAB	+	+	-	0	-	0	0	0	0	4
m	LAB	+	+	+	+	-	0	0	0	0	5
f	LAB	-	+	-	0	+	0	0	0	0	4
t	COR	-	+	-	0	-	0	0	0	0	4
d	COR	+	+	-	0	-	0	0	0	0	4
θ	COR	-	+	-	0	+	0	0	0	0	4
n	COR	+	+	+	+	-	0	0	0	0	5
ɾ	COR	+	+	+	0	+	-	0	0	0	5
r	COR	+	+	+	0	-	-	0	0	0	5
l	COR	+	+	+	0	+	+	0	0	0	5
s	COR	-	+	-	0	+	0	+	0	0	5
ʎ	COR	+	+	+	0	+	+	0	+	0	6
ɲ	COR	+	+	+	+	-	0	0	+	0	6
tʃ	COR	+	+	-	0	-	0	+	+	0	6
ɟ͡ʝ	COR	+	+	-	0	-	0	+	+	0	6
j	DOR	+	+	+	0	+	0	0	0	+	5
k	DOR	-	+	-	0	-	0	0	0	0	4
g	DOR	+	+	-	0	-	0	0	0	0	4
x	DOR	-	+	-	0	+	0	0	0	0	4

It is important to note that while variable, metathesis occurs in all eligible environments in Andalusian, which is consistent with it happening at the level of the timing layer in my theory. Metathesis occurs within words (160a.), across morpheme boundaries (160b.), and across word boundaries (160c.).

(160) /s-p,t,k/ seq. metathesize in Andalusian Spanish (Gilbert, 2022; Horn, 2013)

a.	/ˈpasta/	[ˈpatha]	'pasta'	*root-internally*
	/pesˈtaɲa/	[peˈthaɲa]	'eyelash'	
	/ˈkosta/	[ˈkotha]	'coast'	
	/posˈtal/	[poˈthal]	'postal'	
b.	/des-tapar/	[dethapar]	'to uncover'	*morpheme boundary*
c.	/mas ˈpatas/	[ma ˈphatah]	'more paws'	*word boundary*
	/las taˈpitas/	[la thaˈpitah]	'the small tapas'	
	/las ˈkasas/	[la ˈkhasah]	'the houses'	

Metathesis varies with debuccalization and gemination along sociolinguistic dimensions (Ruch, 2008), illustrated in (161):

(161) Metathesis varies with debuccalization and gemination (Ruch 2008: 78-82, Gilbert 2022: 104)

	Debuccalization	Gemination	Metathesis	
a. /tʃispa/	[tʃihpa]	[tʃip(ː)a]	[tʃipha]	'spark'
b. /pasta/	[patha]	[pat(ː)a]	[pahta]	'pasta'
c. /boske/	[bokhe]	[bok(ː)e]	[bohke]	'forest'

I analyze Spanish metathesis as a way of removing obstruent codas (following Catalán 1971; Mason 1994; Moya Corral and Tejada Giráldez 2020). I define a cover constraint NoCoda[-son], which penalizes [-son] segments associated to a C-slot that is not immediately followed by a V-slot.

(162) NoCoda[-son]: 'No obstruent codas'

For a [-son] consonant segment that is not in word-initial position, it must be associated with a C-slot that is immediately followed by a V-slot.

I illustrate this in (163) by ranking NoCoda over *Mult. Metathesis occurs to preserve the [s], shifting it rightwards instead of leaving it unpronounced (as in c.), yielding the winning candidate (b.).

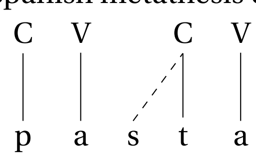
(163)

/pasta/	NoCoda[-son]	*Float	*Mult
a. C V C C V / p a s t a	*!		
☞ b. C V C V / p a s t a			*
c. C V C V / p a s t a		*!	

As a side note, the analysis here does not account for debuccalization, but there are several options on how to implement it. Spreading could be partial, spreading laryngeal features but not oral place. Another possibility is that the metamorph layer transforms coda /s/ into /h/ within roots. The matter of how to analyze debuccalization is somewhat tangential to the broader issue of metathesis, and so I set this aside for the time being.

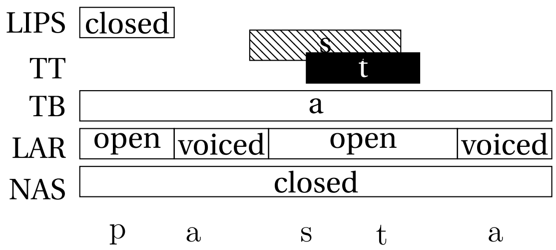
Andalusian Spanish produces an output that is underspecified for gestural order. Unlike Faroese and Meto, no association lines are crossed (164), and so gestural containment is a possibility, but not required. Either of the gestural scores in (165) are compatible with this output:

(164) Spanish metathesis does not involve line-crossing

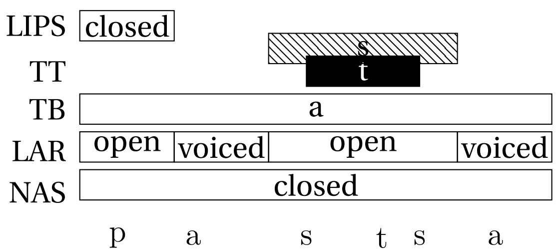


(165) Consequence: Spanish metathesis does not require gestural containment

i. Possible output 1: [pas͡ta] (overlap, but not contained)



ii. Possible output 2: [pasts͡a] (containment)



I follow Parrell (2012) and argue that motor planning provides a pressure for [s] and [t] to start closer together, as in (165ii.), where the gestures are closer to being realized in-phase. However, this preference is expected to be highly dependent on speech rate. The expectation from this is that there should be more variability in Spanish metathesis than in Faroese or Meto.

In Section 3.4.3.1, I argue that this is true: Andalusian Spanish has many cases of incomplete metathesis (e.g. [pahtha]) and of debuccalization without metathesis (e.g. [pahta]). Similar levels of variability have not been reported in the Meto or Faroese patterns, and so the representational distinction between Spanish and these patterns is warranted.

I now go on to present data on phonetic incompleteness (Section 3.4.3.1) and invisibility (Section 3.4.3.2), following the insights of Gilbert (2022).

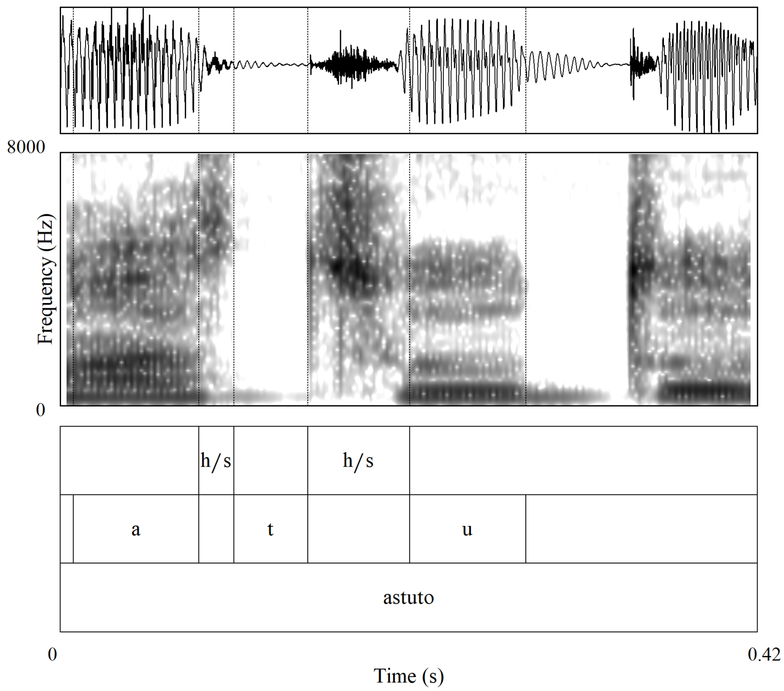


Figure 3.3: Spectrogram of incomplete metathesis in /astuto/ → [a^{h}thuto] ‘cunning’ (Maddie Gilbert, p.c.).

3.4.3.1 Andalusian Spanish: Phonetic incompleteness

In this section, I review evidence that suggests Andalusian Spanish metathesis is phonetically incomplete, and argue that this provides evidence in favor of treating metathesis as gestural overlap (following Gilbert 2022; Parrell 2012; Torreira 2012.[29]

Metathesized /sp st sk/ clusters in Andalusian Spanish can be phonetically incomplete (Gilbert, 2022; Parrell, 2012; Ruch, 2008). In Figure 3.3 of /astuto/ ‘cunning’, there is a period of noise both before and after the stop closure, fully surrounding it. Compare this to Figure 3.4 /kastijo/ ‘castle’, where metathesis is complete.

Incomplete tokens of the type in Figure 3.3 are fairly common, comprising 11% of attested forms (Ruch 2008: 78). Additionally, the duration of presaspiration and postaspiration have bear an inverse relationship — as preaspiration shortens, postaspiration lengthens (Cronenberg et al.,

[29]Special thanks to Maddie Gilbert, for her valuable thoughts and feedback. All spectrograms in this section were generously provided from her fieldwork in Seville in Spring 2023.

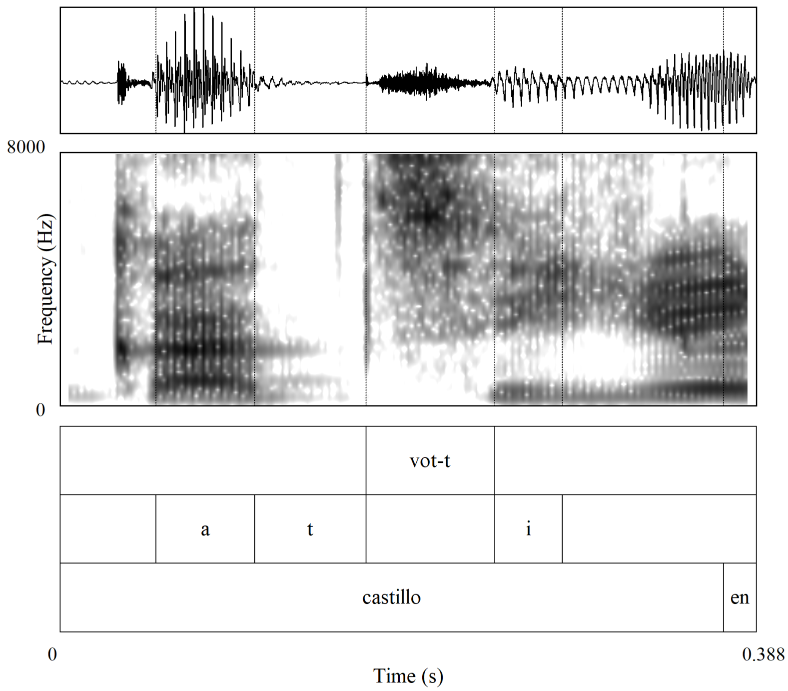


Figure 3.4: Spectrogram of complete metathesis in /kastijo/ → [katsijo] 'castle' (Maddie Gilbert, p.c.).

2020; Parrell, 2012; Torreira, 2012). Cronenberg et al. (2020) argues that this tradeoff relationship is evidence that they result from the same gesture.

This kind of overlap is precisely what my account predicts. The position of the [s] gesture is underspecified, where the [s] can either contain the stop or simply overlap with it. As the [s] drifts rightwards within this underspecified area, the overall duration is expected to be invariant, since on an abstract level, [s] is still associated with just one timing slot.

Similar indications of gestural overlap are also found in /s/-voiced stop clusters (Gilbert, 2022). In comparison to voiced intervocalic stops, these /s/-voiced stop clusters have a longer duration, they are noisier (higher CPP), and have higher intensity ratios (Gilbert 2022: 43). These differences are readily visible in spectrograms, as shown in Figures 3.5 and 3.6. Figure 3.5 shows a word-initial, spirantized /d/ in *desnudo* 'naked'. In comparison, the /sd/ cluster in *desdeña* 'disdain' is considerably noisier with a higher degree of constriction.

From these data, we can conclude that both voiced and voiceless /s/-stop sequences show

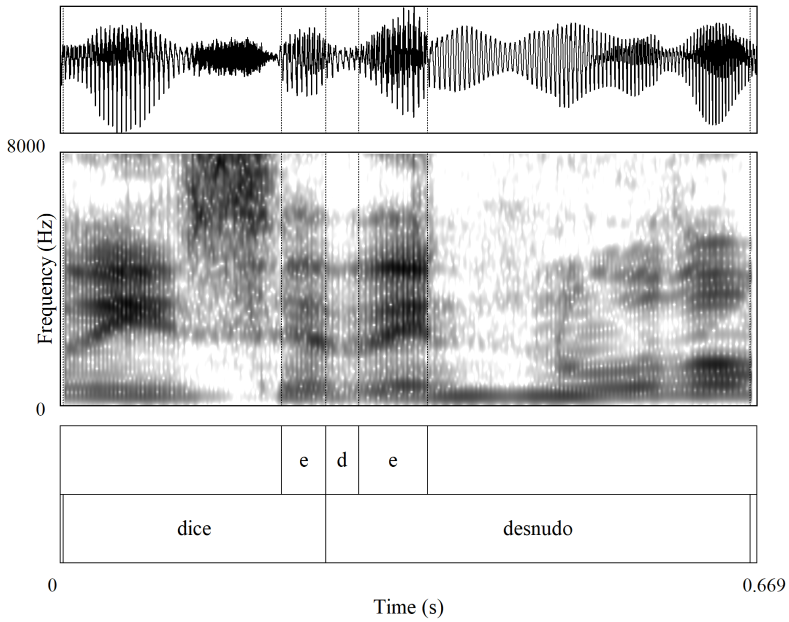


Figure 3.5: Spectrogram of /d/ spirantization in Andalusian Spanish: /desnudo/ → [d̲esnudo] 'naked' (Maddie Gilbert, p.c.).

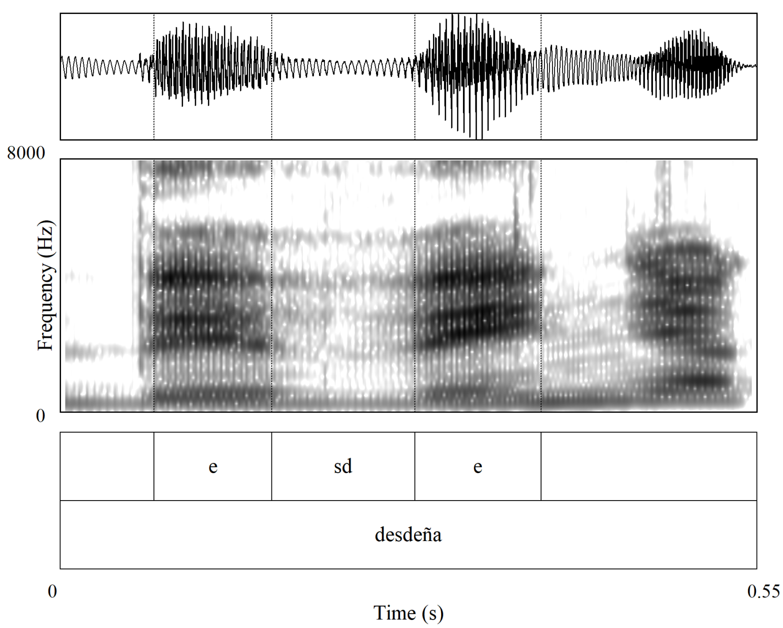


Figure 3.6: Spectrogram of /sd/ overlap in Andalusian Spanish: /desdeɲa/ → [d̲esdeɲa] 'disdain' (Maddie Gilbert, p.c.).

indications of gestural overlap. Voiceless /s/-stop sequences bear pre- and post-aspiration, whereas voiced ones absorb the noise of the aspiration throughout, blending it with the voicing gesture.

In the next section, I turn to invisibility, where I argue that Spanish metathesis, while driven by prosodic requirements, cannot be taken into account when determining stress assignment.

3.4.3.2 Andalusian Spanish: Invisibility

In this section, I review existing evidence that Andalusian Spanish metathesis is invisible. Gilbert (2022) argues that metathesis in Andalusian Spanish is invisible based on an original stress judgment task. The main observation is that Sevillian Spanish speakers do not account for metathesis when judging prosodic well-formedness; metathesis is invisible to weight, even though it appears in response to restrictions on codas. Gilbert therefore concludes that Spanish metathesis does not involve reorganization of abstract segments, but is only a gestural effect that cannot change syllable weight.

Spanish stress assignment is weight-sensitive (Harris, 1983). Antepenults can be stressed only as long as the penult is not heavy (CVC), as in (166).

(166) If a penult is heavy, the antepenult cannot be stressed (Fuchs, 2018; Harris, 1983)

Gilbert (2022) observes that metathesis changes syllable structure (e.g. /CVh.CV/ → [CV.ChV]), and so we might expect them to be able to interact. Do speakers judge syllables where /s/ has metathesized out as heavy (167a.) or light (167b.)?

(167)	a.	/ˈmis.ti.ko/	H́LL	‘mystic(al)’	*before metathesis*
	b.	[ˈmi.thi.ko]	ĹLL	‘mystic(al)’	*after metathesis*

To address this question, Gilbert (2022) conducted a forced-choice task experiment using nonce words with speakers of Sevillian Spanish. Speakers were presented with words with fixed antepenultimate stress, and forced to choose the one that was most well-formed. The target words differed in the quality of the penult: a light CV syllable, a heavy CVs syllable, a heavy CVh syllable, a heavy CVN syllable, or a metathesized syllable, as in (168).

(168) Stress judgement task stimuli from Gilbert (2022)

	No Coda	Coda /s/	Coda /h/	Coda sonorant	Metathesis
Nonce word	lu.ˈma.<u>fa</u>.to	lu.ˈma.<u>fas</u>.to	lu.ˈma.<u>fah</u>.to	lu.ˈma.<u>fan</u>.to	lu.ˈma.<u>fa</u>.tho
UR Penult	CV	CVC	CVC	CVC	**CVC**
Surface Penult	CV	CVC	CVC	CVC	**CV**

The results were unequivocal: speakers prefer light penults, even over metathesized tokens, as in (169).

(169) Gilbert (2022): speakers preferred light penults over heavy and metathesized ones

No Coda		Coda /s/	Coda /h/	Coda sonorant	Metathesis
lu.ˈma.<u>fa</u>.to		lu.ˈma.<u>fas</u>.to	lu.ˈma.<u>fah</u>.to	lu.ˈma.<u>fan</u>.to	lu.ˈma.<u>fa</u>.tho
/LLLL/	*preferred over*	/LLHL/	/LLHL/	/LLHL/	/LLHL/
[LLLL]		[LLHL]	[LLHL]	[LLHL]	[LLLL]

Additionally, metathesized words were judged equally with other types of heavy penults.

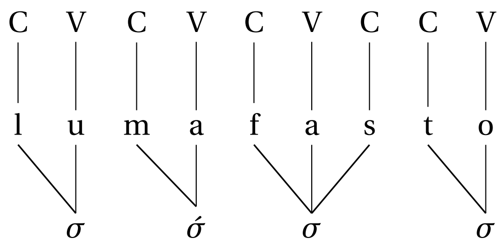
(170) Gilbert (2022): Metathesized words judged equally with other heavy penults

Metathesis		Coda /s/	Coda /h/	Coda sonorant
lu.ˈma.<u>fa</u>.tho		lu.ˈma.<u>fas</u>.to	lu.ˈma.<u>fah</u>.to	lu.ˈma.<u>fan</u>.to
/LLHL/	*judged equally*	/LLHL/	/LLHL/	/LLHL/
[LLLL]		[LLHL]	[LLHL]	[LLHL]

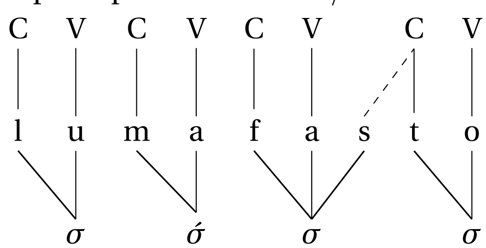
Gilbert argues that these results are consistent with the speakers referencing the UR rather than the SR for determining syllable weight. Metathesized words like [lu.ˈma.fa.tho] (with UR: /lu.ˈma.fas.to/) are uniformly treated as heavy.

This result is what we expect under Lamination Theory. Andalusian metathesis is a timing-layer effect, and does not change syllable structure. It only changes when gestures are aligned in time. Syllabic structure, on the other hand, is based off of strings of segments in the metamorph layer. A nonce word like /lumafasto/ would have the form in (171). The output, despite having one less C-slot in the timing layer, has the same syllable structure in the metamorph layer, shown in (172):

(171) Input representation for /luˈmafasto/



(172) Output representation for /lu.ˈma.fa.tho/: **syllable structure does not change!**



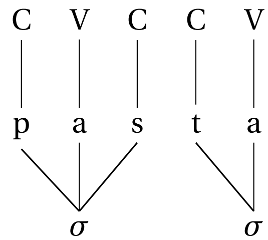
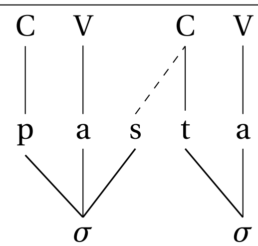
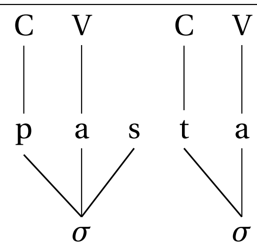
There is an important conceptual question here concerning NoCoda. Can Spanish metathesis really be considered a response to NoCoda, if it doesn't overwrite the syllable structure?

I believe that these facts are not incompatible under the present theory. One such approach is to appeal to serialism. If we order prosodic structure-building early, before other phonology has taken place (see Rasin (2017) for one such proposal), then we expect for the outcome of metathesis to occur too late to change syllable weight. The derivation has already moved on by the time metathesis occurs, and so when speakers reconstruct the derivation, they do not model an interaction between metathesis and weight.

However, there is another possibility that using a layered model opens up: that constraints like NoCoda are simultaneously evaluated at two levels of structure: once in the prosodic level, and again at the timing layer. While metathesis may not change the deep structure violations of NoCoda, it does improve surface violations of NoCoda, and as such will still be favored:

(173) NoCoda (revised): Assign a violation for a segmental coda <u>or</u> for a C-slot that is not followed by a V-slot.

(174)

/pasta/	NoCoda	*Float	*Mult
a. 	**!		
☞ b. 	*		*
c. 	*	*!	

This kind of approach could also be applied to stress-epenthesis interactions, where there are some epenthesis patterns that are visible to stress and those that are not (Alderete, 1995, 1999; Broselow, 1982; Elfner, 2009). The standard approach to these interactions is to appeal to serial ordering of some kind (rules: Mithun and Basri 1986, constraints: Elfner 2009). The other approach, as I have described here, is to expand our inventory of prosodic constraints to allow some to be sensitive to deep structure, and others to be sensitive to both deep structure and surface timing structure. Stress alignment constraints, such as Align(X,R) could therefore come in two varieties: those only sensitive to syllables and those sensitive to both syllables and timing slots (Meto may be one such case of this latter type, see Section 3.4.1).

3.4.3.3 Andalusian Spanish: Summary of analysis

In this section, I reviewed evidence on the Andalusian Spanish /sp st sk/ metathesis pattern, and argued that it results from gestural overlap (pace Cronenberg et al. 2020; Gilbert 2022; Parrell

2012; Torreira 2012). I formalized this as coalescence of two segments onto a single C-slot (ranking: NoCoda, *Float ≫ *Mult).

Similar to Meto and Faroese, Andalusian Spanish metathesis was phonetically incomplete, it occurred in complementary distribution with deletion, and it was phonologically invisible. All three of these things are what we expect if metathesis does not involve abstract reordering of segments.

3.4.4 Interim summary

To summarize, in this section I provided case studies on three languages: Meto, Faroese, and Andalusian Spanish. Metathesis in these languages showed similar characteristics:

1. Phonetic incompleteness
   - ☑ Meto incomplete metathesis (e.g. /manus-es/ → [ma͡ʊnu̯s-es], 3.4.1.1)
   - ☑ Faroese sonorant devoicing (e.g. /fraŋskt/ → [fraŋ̊skt], 3.4.2.1)
   - ☑ Andalusian Spanish incomplete metathesis (e.g. /astuto/ → [astsuto], 3.4.3.1)
2. Co-occurrence with deletion and/or spreading
   - ☑ Meto vowel deletion and diphthongnization (3.4.1.2)
   - ☑ Faroese consonant deletion (3.4.2.2)
   - ☑ Andalusian Spanish consonant deletion (161)
3. Invisibility
   - ☑ Meto metathesis is invisible to consonant deletion (3.4.1.3)
   - ☑ Andalusian Spanish metathesis is invisible to stress assignment (3.4.3.2)

These characteristics are all hallmarks of timing-layer effects, the kind of phonological grammar that produces regular (though surface-level) changes to gestures. Metathesis is thus a kind of covert spreading. Segmental order remains unchanged, and so metamorph-type phonology (e.g. stress assignment, reduplication, allomorphy) all behave as if no displacement has occurred.

In comparison, transposition analyses have to independently assert these three facts. Incomplete metathesis would have to be analyzed as a paradigm uniformity effect, and we would have to stipulate that metathesis is always computed *after* stress or other phonology. In the next section, I turn to morphologically-restricted metathesis, which shows different behavior.

3.5 Morphologically-restricted metathesis

To briefly review, in the preceding sections I've discussed two problems in the typology of metathesis. The first is that of overgeneration: when we allow transposition in phonological grammar, then we overgenerate long-distance and vowel-vowel patterns. Long-distance patterns only occur in morphologically restricted patterns, and vowel-vowel metathesis never occurs at all.

The second problem is undergeneration. Language-general metathesis patterns, when they arise, tend to have several characteristics in common, including phonetic incompleteness, complementarity with deletion patterns, and phonological invisibility. We have just seen case studies confirming these last generalizations, along with arguments that together, these comprise evidence that language-general metathesis is gestural overlap.

However, morphologically restricted metathesis appears to be radically different. There are long-distance patterns, which suggests that transposition may not overgenerate here. I also argue that these long-distance patterns *lack* the same three characteristics discussed for language-general patterns: they do not occur in complementary distribution with deletion, they are not invisible, and they have no reported phonetic incompleteness.

I organize the discussion around two sets of morphologically-restricted reordering patterns: verbal templates and infixation. In the case of verbal templates (Section 3.5.1.1), we find that consonant-vowel reordering does change syllable structure, since it is interpretable to weight-driven stress assignment in Sierra Miwok. This is the exact mirror image of metathesis in Sevillian Spanish, which had no bearing on syllable weight. I conclude that verbal template metathesis is phonologically visible. In infixes (Section 3.5.2.1), I argue that reordering is phonetically complete and cannot involve gestural overlap based on preliminary evidence from Khmer.

The core argument is that two kinds of morphologically-restricted patterns, verbal template metathesis and infixation, require different analyses from the language-general metathesis already discussed. Phonological transposition, if it exists, must be limited to the metamorph layer.

3.5.1 Stem metathesis in verbal templates

In many languages, the order of segments in certain verb stems follows a predictable pattern. The classic way of analyzing this is with templates (McCarthy 1979, 1981, et seq.), where the morphology specifies an abstract CV skeleton and then the phonology fills it out. An alternate approach, however, is to derive these templates in the phonology proper through use of ALIGNMENT and other phonotactic constraints (Zukoff, 2021). In the first approach, verbal templates are fixed by the morphology; in the second, they are fixed by the phonology in a process not so dissimilar from metathesis.

In this section, I review evidence on verbal templates, and conclude that their reordering (if such a thing is actively computed in phonology) must be distinct from the language-general metathesis discussed in Section 3.4. I present an arguments from stress-metathesis interactions in Sierra Miwok.

3.5.1.1 Sierra Miwok: verbal metathesis is visible to stress assignment

In Sierra Miwok (Penutian, Freeland and Voegelin 1951), verbs show templatic behavior — in several morphosyntactic contexts, the order of consonants and vowels is entirely predictable. One way of analyzing these alternations is with verbal metathesis (Stonham, 1990). In this section, I demonstrate that Sierra Miwok verbal metathesis is creates heavy syllables used in stress assignment, which provides evidence that metathesis in this language is phonologically visible.

As a preliminary, Sierra Miwok stress is weight sensitive (Freeland and Voegelin 1951; Stonham

1990: 190).[30] Stress always appears on the leftmost heavy syllable, illustrated in (175). This ends up being the first or second syllable of the stem, and this stressed syllable is always heavy.

(175) Miwok stress is on the leftmost heavy syllable (Freeland and Voegelin 1951: 7, no glosses)

a. *Initial heavy syllables are always stressed*

ˈhaː.naʔ	ˈpat̪.ka.jɨʔ
ˈčaː.ma.jɨʔ	ˈhan.naʔ
ˈwok.liʔ	ˈwit.ta.pɨʔ

b. *Leftmost heavy is stressed when #HH...*

ˈjaː.jaː.liʔ	ˈšak.kaš.ša.kiʔ
ˈmɨː.hɨː.naʔ	ˈčim.t̪eǰ.yaʔ
ˈhuš.šeː.piʔ	ˈhɨj.ʔɨk.sɨː

c. *Leftmost heavy is stressed when #LH...*

ka.ˈwaː.čiʔ	wa.ˈtak.saʔ
ti.ˈmiː.šɨʔ	ka.ˈlaŋ.paʔ

Verbs in Sierra Miwok can appear in four main stem forms, which Freeland and Voegelin (1951) describes as primary, second, third and fourth. Choice of stem is conditioned by tense, aspect and negation suffixes. These stems primarily differ from each other in the order of consonants and vowels, but also can vary by geminating consonants (e.g. [ˈkalːaŋ-i] ‘habitual dancer’, [kaˈlaːŋ-e] ‘dancer’, [kaˈlaŋː-ik] ‘future dancer’).

A summary of these four stem types is given in (176). The order of consonants and vowels in stems second through fourth is predictable from the primary stem.

[30] Stonham describes the pattern slightly differently: If the first syllable is heavy (CVC or CV:), stress it. Otherwise, stress the second syllable and make it heavy if not already.

(176) Four verbal stem types in Sierra Miwok (Freeland and Voegelin 1951: 94-95)

	Primary stem	Second stem	Third stem	Fourth stem
	variable	CVCVC:	CVC:VC	CVCCV
a. ‘to roll’	huˈt̪eːl	huˈt̪elː	ˈhut̪ːel	ˈhut̪le
‘to fall’	poˈlaːŋ	poˈlaŋː	ˈpolːaŋ	ˈpolŋa
‘to wrap’	t̪oˈpoːn	t̪oˈponː	ˈt̪opːon	ˈt̪opno
‘to laugh’	hiˈjaːk	hiˈjakː	ˈhijːak	ˈhijka
‘to hear’	teˈleːj	teˈlejː	ˈtelːej	ˈtelje
b. ‘to seek’	ˈwelšɨ	weˈlɨšː	ˈwelːɨš	ˈwelšɨ
‘to quit’	ˈčelku	čeˈlukː	ˈcelːuk	ˈčelku
‘to suck’	ˈkojpa	koˈjapː	ˈkojːap	ˈkojpa
‘to poison’	ˈt̪ujku	t̪uˈjukː	ˈt̪ujːuk	ˈt̪ujku

Crucially, stress here remains predictable, located on the leftmost heavy syllable of the word. This is important because metathesis in the verbal template is visible to stress assignment. If stress were *not* affected by metathesis, we would expect *[ˈwelɨšː] ‘to seek (2nd stem)’, and so on.

Sierra Miwok is thus the mirror image of what we conclude from Gilbert (2022)’s Andalusian Spanish stress judgement task discussed in Section 3.4.3.2. While Spanish metathesis was invisible to stress assignment, here the Sierra Miwok verbal metathesis is visible to it. From this, I conclude that verbal templates involve segmental reordering, rather than gestural overlap.

We can analyze Sierra Miwok verbal templates as segmental transposition in the metamorph layer. For example, a simple analysis would have *FINALC (the constraint against word-final consonants) outrank LINEARITY for the fourth stem. The second and third stems would have LINEARITY dominated by FINALC (requiring word-final consonants) as well as separate constraints for a heavy word-final syllable or a heavy word-initial syllable. Initial syllable faith (Beckman, 1998) could be used to prevent metathesis at the left edge of the stem.

3.5.2 Infixation

While segmental metathesis is typologically rare, its logical counterpart in morphology — infixation — is robustly attested. It remains controversial, however, whether it is driven by phonotactic constraints (Horwood, 2004; McCarthy and Prince, 1993a; Wolf, 2008, a.o.) or parochial subcategorization frames (McCarthy and Prince, 1993b; Yu, 2007, 2003). Kalin (2022) has recently argued that infixes are underlyingly prefixes and suffixes, solidifying infixation as a kind of reordering phenomenon.

Depending on what analysis for infixes we adopt, we may expect for infixes to resemble metathesis. For example, in the view where infixation is phonotactically driven, we may expect metathesis and infixation to be quite similar. They both involve phonotactically-driven displacement inside a stem, and, depending on the analysis, may even be militated against by the same constraints. Horwood (2004), for instance, argues that infixes and metathesis both violate LINEARITY.

In this section, I provide some initial evidence that suggests infixation is different from language-general metathesis. I focus on infixation in Khmer, and observe that there is no obvious phonetic incompleteness in consonant-infix clusters in this language. I hypothesize that infixes reordering is phonetically complete, and flag the issue of how infixation is phonetically implemented for future study. Based on the available evidence, I hypothesize that the displacement mechanism for infixes is true reordering, and as such cannot belong in the timing layer.

3.5.2.1 Khmer: infixation is phonetically complete

Khmer (Austro-Asiatic) has nominalizing infixes ⟨ə(m)⟩, ⟨ə(n)⟩, and ⟨b⟩, which surface before the first vowel of the stem (Diffloth, 1977; Haiman, 1998).

(177) Khmer: NMLZ infix ⟨*m,n*⟩ fully reorders past first C

	Root	Infixed form	
a. ‘to be strong’	klaŋ	k⟨əm⟩la ŋ	‘strength’
b. ‘to trade’	cuəɲ	c⟨əm⟩uəɲ	‘merchant’
c. ‘to beg’	som	s⟨m⟩om	‘beggar’
d. ‘to spin (silk)’	kaa	k⟨n⟩aa	‘spindle’

While no longer productive in modern Khmer, there are well over a hundred words that combine with these infixes (Diffloth, 1977), and speakers are often aware of them. Modern Khmer speakers often no longer pronounce the nasal, and these infixes surface as either ⟨ə(n)⟩ or ⟨b⟩.

Khmer infixation has not been found to be phonetically incomplete. In Figure 3.7, I show a spectrogram of the infixed form /k⟨əm⟩la ŋ/ ‘strength’ (177a.).[31] Despite this being displacement of one sound across another, infixation here does not appear to occur via spreading. There is no nasalization on the first consonant, or increased voicing in comparison to the bare form [klaŋ] ‘to be strong’, shown in (b). Aside from the presence of the infixed schwa, the closure period of these two [k]’s are quite similar.[32]

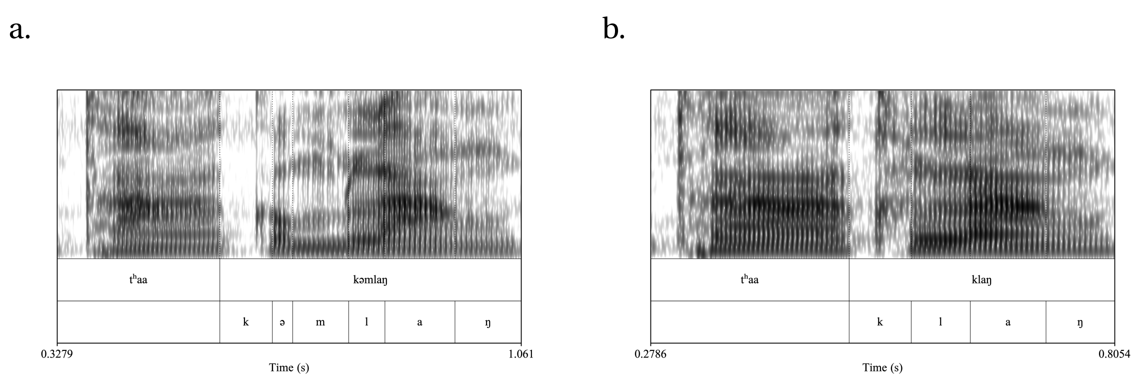


Figure 3.7: Khmer does not show increased voicing on [k] when comparing (a) infixed [k⟨əm⟩la ŋ] ‘strength’ to (b) non-infixed [klaŋ] ‘to be strong’.

[31] Recordings here are adapted from Kirby (2014), which examined consonant-consonant transitions in Khmer (infixation did not play a role in the study).

[32] Non-infixed [klaŋ] does appear to have more aspiration on the [k]. Orthography could be responsible for this, since [klaŋ] ‘strong’ is spelled with the aspirated [k^hɑ] symbol, but [k⟨əm⟩la ŋ] ‘strength’ is spelled with the unaspirated [kɑ].

To sum up, Khmer infixation does not obviously bear the same kind of phonetic incompleteness found in language-general metathesis. The next question is whether or not Khmer infixed sequences are acoustically identical to their non-infixed counterparts. There is no data available on this at this time, and so I set it aside for future work. In the interim, I hypothesize that these cases are phonetically complete.

3.5.3 Interim summary

In this section, I argued that morphologically-restricted patterns do seem to reorder segments. Evidence came from phonetics (Khmer) as well as phonological interactions with stress (Sierra Miwok), which support the conclusion that these forms of displacement are phonologically visible. I hypothesize that true reordering is limited to morphophonological grammar.

These differences between language-general metathesis and morphologically-restricted metathesis are not easily reconciled. As discussed in Section 3.1.1, once one allows transposition in grammar, then it is difficult to not overgenerate. Here I have addressed this problem by advocating for separation of the phonological grammar into multiple layers, each which has its own variety of GEN.

I now continue on to show how my theory does not overgenerate long-distance metathesis or vowel-vowel metathesis in the timing layer, and to discuss putative counterexamples. I demonstrate that if we define locality in gestural terms, rather than segmental ones, then we derive the correct typology.

3.6 Locality and long-distance metathesis

In this section, I return to the problem of long-distance metathesis, and argue that my analysis does not overgenerate.

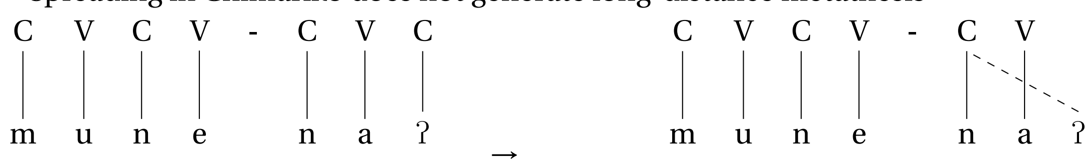
Let's return to the Chimariko (Hokan, Jany 2009), which in Section 3.2 I argued was a case of morphologically-restricted, long-distance metathesis. A suffix appears as ʔCV after vowels and CVʔ after consonants, as shown in 178.

(178) Chimariko non-local metathesis: ʔCV → CVʔ (Jany 2009: 42)

	V_	C_
a. /jaʔ/ 'again'	[h-išehe-tku-ʔja-t]	[h-imam-jaʔ-t]
	3-lead-DIR-again-ASP	3-see-again-ASP
	'She brought some more (dogs)'	'He sees him again'
	[h-isumta-ʔja-kon]	[h-aʔatok-jaʔ-kon]
	3-look.at-again-FUT	3-return.hither-again-FUT
	'He is going to look at it again'	'He is going to come back'
b. /jeʔw/ 'REFL'	[h-ak^{h}o-ʔjew-taʔn-ta]	[h-ok'im-jeʔw-ta]
	3-kill-REFL-PST-ASP	3-hang-REFL-ASP
	'He has killed himself'	'He has hanged himself'
c. /naʔ/ 'plant'	[mune-ʔna]	[hak'ew-naʔ]
	acorn.of.black.oak-plant	nut.of.sugar.pine-plant
	'Black oak'	'Sugar pine'

I claim that this pattern not possible to derive in the timing layer. Recall, the timing layer can only manipulate slots and association lines, it cannot change segmental order in the metamorph layer. Let's give it a try, focusing on /mune-naʔ/ → [mune-ʔna] 'black oak'. (For now, we'll set aside the question of what drives metathesis, and focus just on the representations.) Naively, we could assign the CV representation in (179) below:

(179) Spreading in Chimariko does not generate long-distance metathesis



/mune-naʔ/ *intended*: [mune-ʔna]

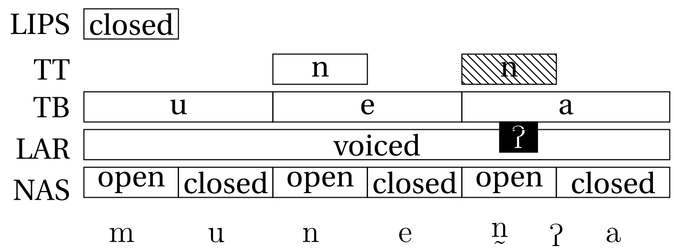
derived: [mune-nʔː], or others (see (180) below)

However, this does not generate the metathesis we desire. When we transform this into a gestural score, the Law of Order Preservation gives us four conceivable outputs, as in (180). However, only (180iv.) is possible because it is the only one compatible with the Law of Specified Gestures.[33]

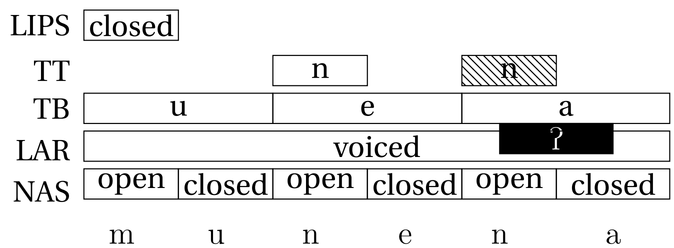
[33] The scores in (180i.) through (180iii.) can only occur when the glottal stop is less specified than the vowel, but then we would not expect for the glottal to be able to spread across the vowel to begin with.

(180) Four outputs from Chimariko spreading in (179): none generates desired output [mune-ʔna]

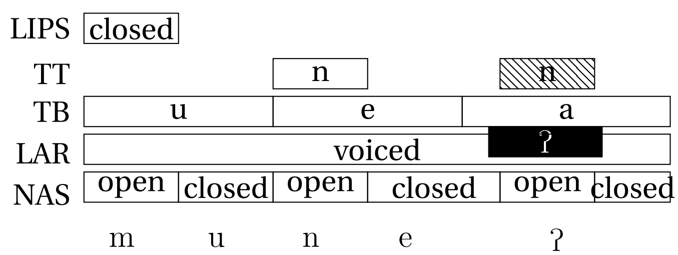
i. Impossible output 1: *[mune-n̰a] (glottal contained in vowel and nasal)



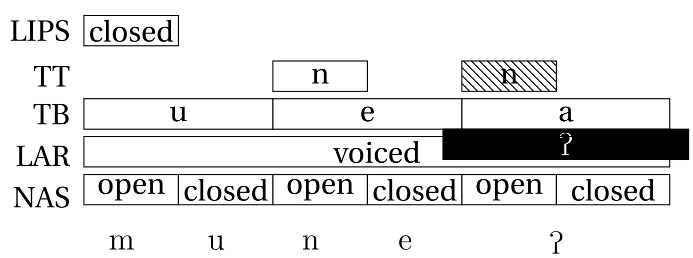
ii. Impossible output 2: *[mune-nʔa] (glottal contained in vowel, but not nasal)



iii. Impossible output 3: *[mune-ʔnʔa] (glottal contains nasal but not vowel)

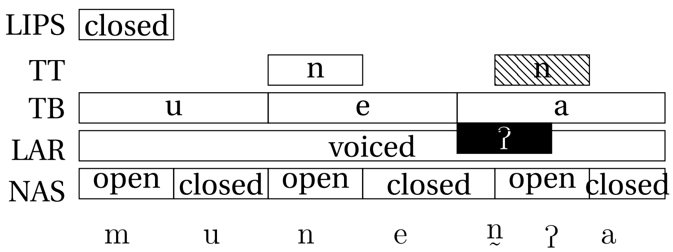


iv. **Possible** output 4: *[mune-ʔː] (glottal contains vowel and nasal)



Crucially, the desired output [mune-ʔna] (shown in (181) below) is not compatible with Order Preservation! Recall, Order Preservation says that if one segment precedes another in the input, then either the first segment's onset should be first, or the last segment's onset should be last. When we examine the order of [n] and [ʔ], neither is true: [ʔ] starts first, and [n] ends last.

(181) Desired output [mune-ʔna] not compatible with Order Preservation



The best that spreading can do is containment — [mune-ʔnʔa], as in (180iii.) above.

I therefore claim that my analysis does not overgenerate precisely where we need it not to. It allows gestures to stretch and drift, but only within a certain range of their original position. Part of the gesture must always remain anchored near its original position.

Now I turn to language-general metathesis pattern in De'kwana (Cariban). I argue that when we examine this pattern gesturally, this pattern is not long-distance. My analysis is able to capture the De'kwana data.

3.6.1 De'kwana Carib: Long distance metathesis? Not really.

Let's turn back to De'kwana (Cariban, Hall 1988), which in Section 3.1.2 was one of the languages reported to have phonetically incomplete metathesis. I reproduce the forms in (182) below:

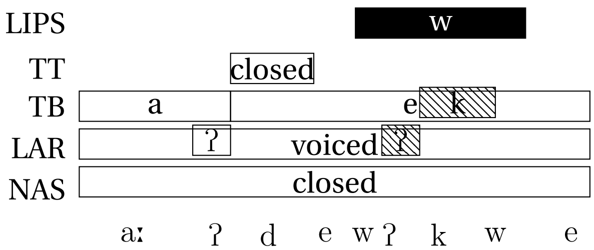
(182) De'kwana wC → Cw metathesis appears long-distance in (c.), (Hall 1988: 239)

a.	/aːwdaːho/	→ [aːwdwaːho]	∼ [aːdwaːhoɲa]	'garden'
b.	/tadaːwde/	→ [tadaːwdwe]	∼ [tadaːdwe]	'to grate'
c.	/aːʔdewʔke/	→ [aːʔdewʔkwe]	∼ [aːdeʔkwe]	'speech'

From a segmental perspective, the incomplete form [aːʔdeʔkwe] in (182c.) is long-distance: the landing site of [w] is more than one segment away from its original position.

However, under my analysis, the pattern isn't necessarily long-distance at all — it can easily be derived through spreading, as I now show. The glide spreads across the glottal stop and docks on the same C-slot as [k], shown in (183a.). This representation can then be translated into the gestural score in (183b.).[34]

(183) De'kwana metathesis is not long-distance: /aːʔdewʔke/ → [aːʔdewʔkwe] (182c.)



Thus, while De'kwana gives the impression of long-distance displacement, the glide gesture remains anchored in its original position due to Order Preservation, before the glottal stop. The timing layer cannot stretch this gesture any farther, since that would require changing the precedence relations of the segments. In day-to-day speech, motor planning is expected to obscure where the glide is anchored. As speech rate increases, the glottal stop and glide should become more in-phase so that the [ʔ], [k], and [w] start in unison, pushing pronunciations from the derived [aːʔdewʔkwe] towards [aːʔdeʔkwe].

3.6.2 What rules out long-distance spreading?

What is to prevent long-distance spreading? Since line-crossing is licit, the only real limitation to spreading is the restriction against like spreading over like (the Rule of Most Specified). Beyond this, what is to prevent a highly specified segment from spreading across multiple gestures?

The answer is absolutely nothing. As long as there is a constraint ranking that favors it, long-distance spreading is expected to be licit.

Due to the *Law of Order Preservation*, however, long-distance spreading does not equate to long-distance metathesis. One edge of the spreaded gesture must remain anchored its original

[34]We can confirm that Order Preservation is respected: [w] starts before [ʔ] and [k], and so it may end at any time.

position,[35] and so long-distance spreading will produce a lengthened, contiguous gesture that spreads from its original position to where it lands.

This, of course, is not metathesis: it's harmony. I take it as an advantage of my analysis that I do not rule this out. Spreading is the classic way of analyzing harmony patterns in Autosegmental Phonology (Clements, 1977, 1980; Clements et al., 1982; McCarthy, 1984b, a.o.). (That said, a difference between my account and classic Autosegmental ones is that I do not need to spread multiple times in order for all the intervening segments to be affected. Spreading represents gestural lengthening, and so harmony only requires a segment to spread to its farthest point, crossing the association lines in between.) Long-distance spreading therefore does not overgenerate, but fills a much-needed cell in the typology.

3.6.3 Putative counterexamples: Lezgian and Mutsun

In this section, I briefly discuss two putative counterexamples to my analysis: Lezgian and Mutsun. Lezgian could be considered a counterexample because labialization metathesis appears long-distance, moving fully past an intervening consonant (e.g. $\mathrm{tseg^wer} \sim \mathrm{ts^weg}$ 'hole'). Mutsun also appears to be a counterexample because it displaces a [k] fully past a vowel and a nasal (e.g. [-mak] ∼ [-kma] 'PL'). I argue that these patterns are not long-distance (Lezgian, Section 3.6.3.1) or not general (Mutsun, Section 3.6.3.2).

3.6.3.1 Lezgian

In Lezgian (Caucasian, Haspelmath 1993), contrastively labialized consonants lose their labialization in word-final position. When the word-final vowel is not rounded, labialization metathesizes leftwards onto the first consonant of the stem (184):

[35] The reasoning goes like this. In a sequence of segments ABCDE where C spreads to E, then the onset of B must still precede the onset of D. When spreading goes the other direction, when C spreads to A, then the offset of C must remain after the offset of B.

(184) Lezgian: labialization metathesis (Haspelmath 1993: 59-60)

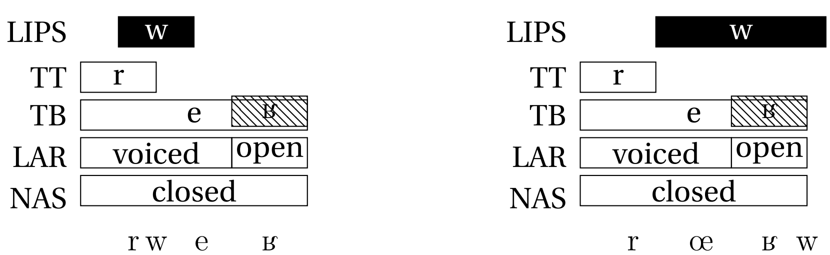
	root	plural	singular	
a.	/tseg^{w}/	tseg^{w}er	ts^{w}eg	‘ant’
b.	/t’ek^{w}/	t’ek^{w}er	t’^{w}ek	‘hole’
c.	/tark^{w}/	tark^{w}er	t^{w}ark^{h}	‘pestle’
d.	/reʁ^{w}/	reʁ^{w}er	r^{w}eʁ^{h}	‘mill’

Haspelmath (1993) also reports that for some speakers, labialization spreads onto the vowel, not the preceding consonant. Forms like /reʁ^{w}/ and /t’ek^{w}/ are therefore pronounced as [rœʁ] ‘mill’ and [t’œk^{w}].

Depending on how one represents labialization, Lezgian metathesis may or may not be a long-distance pattern. If labialization is simply a part of the final consonant and has no inherent order, then this is not long-distance metathesis at all: the labialization simply drifts across the vowel, as shown in (185a.) below. However, if labialization *is* ordered after the final consonant (like a sequence of segments), then surface metathesis would be long-distance. We would expect speakers in this case to be forced to round the vowel when they spread leftwards, shown in (185b.), since the offset of the labialization must remain after the [ʁ].

(185) Lezgian labial metathesis as spreading

a. Metathesis speakers: [r^{w}eʁ] ‘mill’ b. Rounding speakers: [rœʁ] ‘mill’



Spreading thus correctly derives the behavior both kinds of speakers, those who metathesize and those who round. The only difference is whether they analyze labialization as a secondary articulation or as a consonant-labial cluster. I conclude that Lezgian displays a language-general, gesturally local metathesis pattern.

3.6.3.2 Mutsun

Mutsun (Costanoan, Okrand 1977) is a language that has been claimed to have non-local metathesis (Carpenter, 2002). The pattern is that the plural suffix alternates between [kma] after vowels (186a.), and [mak] after consonants (186b.).

(186) Mutsun: long-distance metathesis in plural (Okrand 1977: 136)

	singular	plural	
a.	rukka	rukka-kma	'houses'
	toːt̪e	toːt̪e-kma	'deer'
	sinni	sinni-kma	'children'
	rumme	rumme-kma	'arroyos'
	relo	relo-kma	'clocks'
	huttu	huttu-kma	'bellies'
	ʔonje	ʔonje-kma	'companions'
b.	[wimmah]	[wimmah-mak]	'wings'
	[ruːk]	[ruːk-mak]	'strings'
	[kahhaj]	[kahhaj-mak]	'head lice'
	[ʔinnis]	[ʔinnis-mak]	'sons'

However, in the locative, the pattern is different. Again we have a CCV form after vowels (187a.) and CVC form after consonants (187b.), but here metathesis is local: [tak] alternates with [tka], not *[kta].

(187) Mutsun: local metathesis in locative (Okrand 1977: 154)

	nominative	locative	
a.	[ʔama]	[ʔama-tka]	'body'
	[pire]	[pire-tka]	'world, land'
	[siː]	[siː-tka]	'water'
	[ʔotʃo]	[ʔotʃo-tka]	'ear'
	[ʔissu]	[ʔissu-tka]	'hand'
b.	[ʔurkan]	[ʔurkan-tak]	'mortar'
	[siːt]	[siːt-tak]	'tooth'
	[ʔanjis]	[ʔanjis-tak]	'other'
	[t̪arah]	[t̪arah-tak]	'sky'

It should be clear that my spreading analysis cannot derive Mutsun. For one, it involves spreading of an obstruent across a nasal (186) or another obstruent (187), which should both be ruled out by *the Rule of Most Specified*. The pattern is also long-distance in (186).

I take the fact that spreading can't derive this as a benefit of my analysis, because Mutsun, I argue, doesn't appear to be language-general at all. The plural and locative suffixes are the *only* ones that metathesize in Mutsun. Others, like the diminutive suffix /knisʲ/, never metathesize. Instead, after vowels it is [knisʲ] (e.g. [mukyu-knisʲ] 'old woman') and after consonants it is [nisʲ] (e.g. [meːtʃik-nisʲ] 'fog', Okrand 1977: 139-140). This is not a perfect argument, because the diminutive differs from the plural/locative suffixes in being CCVC vs. CCV.[36] However, there are no other CCV suffixes in Mutsun, so this is best we can do.

Mutsun metathesis is also unusual in the qualities of the consonants involved. In the typological survey, no other productive stop-stop metathesis patterns were found in either language-general or morphologically-restricted patterns. Regardless of whether Mutsun is language-general or not, it is unusual.

To sum up, I treat Mutsun as having morphologically-restricted metathesis, rather than language-general metathesis. For the plural and locative suffixes, there is a morphologically-indexed *CCC constraint that dominates LINEARITY. Mutsun metathesis thus fully reorders segments in the metamorph layer, but only for the locative and plural. My analysis of metathesis as spreading in the timing layer cannot derive this pattern, but I take this as a benefit of the analysis because Mutsun metathesis is not general. The timing layer does not undergenerate, but derives the appropriate gap.

3.7 Alternatives

In this chapter, I have made two claims about the metathesis in phonology:

1. Language-general metathesis is spreading, not transposition.

2. Phonology must be separated into two modules: one which can fully reorder sounds, one which cannot.

In this section, I briefly review some alternatives, such as fusion in Harmonic Serialism

[36] The idea being that metathesis could be blocked by the complex coda (*[meːcik-niks]), which are also not permitted in Mutsun (Okrand 1977: 64).

(Section 3.7.1), transposition in Stratal OT and Cophonologies (Section 3.7.2), and learning (Section 3.7.3).

3.7.1 Fusion in Harmonic Serialism (Takahashi, 2018, 2019)

Takahashi (2018, 2019) argues against transposition in GEN in response to similar overgeneration issues I discussed in Section 3.1.1. Takahashi proposes that all metathesis is the successive application of fission and coalescence, cast in a serial OT framework. So, derivation of Rotuman /pure/ to [puer] involves two steps: fusion of $/\text{pur}_1\text{e}_2/ \rightarrow [\text{pur}_{1,2}]$, and then fission $[\text{pur}_{1,2}] \rightarrow [\text{pue}_2\text{r}_1]$.

Takahashi uses this analysis to (a) remove several long-distance predictions and (b) derive complementary deletion and metathesis patterns in Rotuman, where templatic word shape determines the alternations present.

While Takahashi's analysis is similar to mine by removing transposition from GEN, they otherwise differ quite substantially. Reordering in Takahashi's account is eventually complete, it simply takes a couple derivational steps to get there. The matter of how to derive phonetic incompleteness and phonological invisibility would need to be explained.

One such option would be to explain it in derivational terms, where later links in the candidate chain are more likely to be gradient. However, this does not necessarily predict that phonological invisibility and phonetic gradience go hand-in-hand. I predict that they should; from here on it is an empirical question.

Takahashi's analysis also undergenerates, since it cannot handle long-distance metathesis that involves gestures (such as Lezgian). As demonstrated in Section 3.2, long-distance metathesis does exist, it just bears morphological restrictions. To account for this, the fusion alternative would have to state that all of these examples are allomorphy that are not computed in phonological grammar. There is thus no escape from needing two kinds of grammar to capture the facts: the disagreement ends up being whether or not phonologically-conditioned allomorphy counts as phonology.

3.7.2 Transposition in Stratal OT and Cophonology Theory

Stratal Phonology (Bermudez-Otero 1999, 2003, Kiparsky 2000) and Cophonology Theory (Orgun 1996, Inkelas 1996, Anttila 1997) could also be used to derive many of the patterns discussed in this chapter. Under this alternative, morphologically-restricted patterns would be derived early on (in either an early stratum or a structurally low Cophonology), which would account for why these patterns are visible to other phonology, but language-general metathesis is not.

For the phonetic incompleteness facts, again these alternatives fare well. Earlier in this chapter, I demonstrated that language-general patterns are incomplete, and appear to occur via gestural overlap (Section 3.4). To derive this, the Stratal OT / Cophonology alternatives would need to stipulate that the final derivational level produces phonetically gradient forms (a la Lexical Phonology, Kiparsky 1982; Mohanan 1982, et seq.).

However, these alternatives run into a problem when we consider long-distance metathesis. The fact is that long-distance metathesis is only tolerated in morphologically-restricted patterns, but never language-general ones. Stratal OT and Cophonology theory could account for this by stipulating that the final derivational level can never contain segments that violate LINEARITY multiple times (cf. LIN_2, Horwood 2004). But, this solution is at odds with a fundamental assumption of these theories: Namely, that morphophonological and language-general phonology is essentially the same, but only differs in when it applies. (This is the Phonological Uniformity hypothesis from Chapter 1.)

The fact that long-distance metathesis is *only* possible at early derivational levels directly contests phonological uniformity. Stratal OT and Cophonology Theory could adapt, and also say that early phonology differs from late in its ability to reorder. This could be accomplished by only allowing transposition at early levels of phonology, but never the last one.

It should be clear that the resulting analysis begins to closely resemble my own. There are two kinds of phonology: one that produces gradient outputs and cannot transpose, and another kind that can reorder and produces categorical outputs. My analysis unifies these facts representationally, whereas a Stratal or Cophonology alternative would need to assert them separately.

3.7.3 Learning

A third alternative that I have not discussed much yet is learning. A significant amount of contemporary phonology seeks to explain the typology in terms of learnability: if a pattern is hard to learn, it may never arise in the typology even if there are no formal restrictions against it (e.g. midpoint pathology, Stanton 2016). These explanations vary on exactly how abstract they make their learners: in some cases, learnability is measured from acquisition data (Braine, 1974; Friederici and Wessels, 1993; Jusczyk et al., 1993; Sundara et al., 2021; White and Sundara, 2014); in others, it is measured from computational models (Boersma and Hayes, 2001; Boersma et al., 1997; Graf, 2017; Heinz, 2010; Heinz and Riggle, 2011; Tesar, 1997; Tesar and Smolensky, 1995, 2000).

Given the data from children, the idea that metathesis is difficult to learn is dubious. Children are well-known to spontaneously metathesize, and have been reported to do it consistently for certain types of segment sequences (Kappa, 2002; Lust, 2006; Smith, 1973). Child metathesis does not seem to stem from problems with perception, however. Smith (1973) reports one such case, where a child perceives the difference in what an adult them to say, but produces the metathesized form regardless:

(188) Smith (1973): Child metathesis does not stem from perception

Interaction 1

ADULT: "Say *icicle* ([aɪsɪkəl])"

CHILD: "[aɪkɪtəl]"

Interaction 2

ADULT: "Say [aɪkɪtəl]."

CHILD: "[aɪkɪkəl]."

(Child then asks what [aɪkɪkəl] means.)

Note here that the child is also doing long-distance metathesis. (The child reverses the order of coronal and velar consonants in Interaction 1.) From this, it's clear that the typology of metathesis in adult grammars is unlikely to be explained from child acquisition data alone.

If we allow a more abstract idea of learning, however, it's actually possible to create a learning-based account that is entirely compatible with the facts I have presented here. For instance, we could say that there are two ways that people learn sound patterns: one way over sounds, and another way over morphologically-related forms. Crucially, these two strategies are not the same. Long-distance metathesis can only be learned over morphologically-related forms.

These two strategies also differ in the ease with which reordering is learned. While metathesis is hard to learn over just sounds, it is much easier to learn over a morphologically-restricted domain in the lexicon. We can connect this to the fact that morphologically-restricted patterns are more common than language-general ones.

This leads to a practical question: If two learning strategies exist, then what cues are available to the learner to discover which learning strategy to use? I have already discussed two: phonetic incompleteness and phonological invisibility, which both cue the "just sound" (timing layer) strategy. Now, I offer one that cues the morphophonological strategy (metamorph layer): allomorphy.

In all of the languages surveyed, language-general metathesis is never visible to allomorph selection. By contrast, morphologically-restricted metathesis is visible. An example comes from

Chimariko (Jany, 2009). There are two allomorphs for the aspectual suffix: *-t* (after vowels) and *-ta* (after consonants), as in (189a.).

In (189b.), we see that metathesis of [qtu] ∼ [q^{h}ut] 'in water' is visible to allomorph selection. The allomorph selected is consistent with the surface order of the affix. (If metathesis was not visible to allomorph selection here, we would expect to get the same allomorph for both forms in (189b.).)

(189) Chimariko metathesis (b.) is visible to allomorph selection (a.) (Jany 2009: 40)

	-t / V_	*-ta* / C_
a.	[h-iwo-t]	[h-uwa-m-ta]
	3-sit-ASP	3-go-DIR-ASP
	'He sat'	'He went forth'
b.	[y-eʔa-<u>qtu</u>-t]	[ʔ-iwin-<u>q^{h}ut</u>-ta]
	1SG.-get-in.water-ASP	1SG.A-dump-in.water-ASP
	'I get in the water'	'I dumped them in water'

This result is expected under my analysis. Chimariko metathesis is morphologically restricted, and so it fully reorders segments. The surface order (which is the same as the segment order) should be therefore visible to morphophonology such as allomorph selection. Speakers know this, and so when they are learning the Chimariko pattern, they have another reason to adopt the morphophonological version of metathesis.

The takeaway here is that the distinction between phonological layers can also be understood as a disinction between learning strategies. There are many cues available to learners to help them choose which learning strategy to use. The key fact is that these different strategies have different outcomes, and so phonology does not have a single kind of learning, just as it does not have a single kind of GEN.

3.8 Conclusion

In this chapter, I have made a strong claim: metathesis is not a homogeneous phenomenon, but can be separated into two distinct typologies, one for language-general metathesis, and another for morphologically-restricted metathesis.

I have presented several arguments along these lines, based on both case studies and typological surveys. I demonstrated that long-distance metathesis only occur as a morphologically-restricted pattern. I have also argued that language-general metathesis often bears several phonetic and phonological characteristics: it is phonetically incomplete, it is in complementary distribution with deletion, and certain kinds of phonology is blind to the fact that metathesis has occurred at all. These characteristics are summarized in (190) below:

(190)

Language-general metathesis	**Morphologically-restricted metathesis**
Overlaps gestures (spreading)	Transposes segments
Must be gesturally local	Can be long-distance
Driven by global phonotactics	Driven by arbitrary reqs. of morphemes
Order is preserved by phonetics	Order not preserved by phonetics
Complementary distr. w/ del. & spreading	–
Phonologically invisible	Is visible to other (morpho-)phonology

To derive these facts, I propose that language-general metathesis occurs via spreading, and fails to reorder sounds fully. On the other hand, morphologically-restricted metathesis does fully reorder sounds. The consequence is that transposition, if it exists, must be limited to morphophonological grammar, and can never occur in patterns conditioned only by sound.

If true, this proposal has rich implications for the architecture of phonological grammar. In order to rule out complete reordering for language-general patterns, we must separate phonology into two modules. Here, I have offered one such proposal based on phonological layers. The GEN of the "metamorph" morphophonological layer can reorder fully, but GEN in timing layer is order preserving.

Chapter 4

Copy Epenthesis

4.1 Introduction

In this chapter, I focus on the typology of copy epenthesis patterns. Copy epenthesis, like reduplication, results in a surface segment being heard more than once in the output. An example of copy epenthesis is provided below, from the Dravidian language Kolami.

(191) Copy epenthesis: Kolami (Emeneau 1955: 18-19, via Kawahara 2007: 24)

a.	/ajk/	ajak-t	'sweep-PST'	cf.	ajk-atun	'sweep-PRS'
b.	/erk/	erek-t	'lit (fire)'		erk-ur	'light.fire-IMP'
c.	/sivk/	sivik-tin	'became rotten'			
d.	/teḍp/	teḍep	'cloth'		teḍp-ul	'cloths'
e.	/tupk/	tupuk	'gun'		tupk-ul	'guns'

The question is how identity is attained between the original vowel and epenthetic copy. There are two main analyses: (i) spreading (Akinlabi, 1993; Bugenhagen et al., 1991; Kawahara, 2007), where a single vowel lengthens past an intervening consonant, and (ii) surface correspondence, where an epenthetic vowel mimics qualities of the original in a way not so dissimilar to reduplication (Kitto and de Lacy, 1999; Stanton and Zukoff, 2018). While arguments have been made in each direction, the choice of analysis remains contentious.

In this chapter, I offer another argument in favor of analyzing general patterns of copy epenthesis as spreading. I observe that when copy epenthesis patterns are general, they almost always bear segmental restrictions. This differs from partial reduplication, which is rarely sensitive to quality of participating and intervening sounds.

This observation becomes more striking when we compare copy epenthesis to metathesis. Just as consonants and vowels can move through "transparent" consonants in metathesis (e.g. sonorants, stridents, and laryngeals, Chapter 3), vowels can spread through the same set of consonants in copy epenthesis. Vowels rarely spread through non-strident obstruents.

I therefore contend that there is a tradeoff between generality of a pattern and opacity of intervening segments: as a pattern becomes more general, more segments block copying; whereas as a pattern is morphologically restricted, it often applies without further reference to segmental quality (cf. Hall 2003: 80). I argue that in a spreading-based account, this is expected: spreading is about gestures, and so the quality at hand should be important.

In comparison, in a correspondence-based approach, we would expect all cases of apparent segmental opacity to be explained as AGREE (Lombardi, 1999) or other TETU markedness effects (Stanton and Zukoff, 2018). TETU effects are therefore expected to be equal between host-epenthetic correspondence and base-reduplicant correspondence in the typology at large. However, this is not the case: copy epenthesis has more. In a correspondence analysis, the asymmetry between reduplication and copy epenthesis is thus left unexplained.

I therefore contend that while spreading is possible in timing GEN, that long-distance correspondence and copying is not. I follow Kawahara (2007) and argue that spreading is the only way for general epenthetic segments to assimilate with surrounding sounds. There are no surface segment-to-segment correspondence relationships in representations in the timing layer. My analysis states that VC metathesis and copy epenthesis are the same, except that copy epenthesis leaves more of the vowel in its original position. Long-distance correspondence, if it exists, can only occur in the metamorph layer.

4.1.1 Roadmap

The chapter is structured as follows. Section 4.2 provides a brief overview of the two main competing analyses for copy epenthesis: correspondence and spreading. In Section 4.3, I present the results of a typological survey and argue that the typologies of copy epenthesis and partial reduplication are distinct. Section 4.4 introduces the analysis and applies it to blocking in consonant epenthesis in Section 4.5. Section 4.6 discusses the absence of non-local consonant copying patterns (following Kawahara 2007), and Section 4.7 demonstrates that certain kinds of prosodic identity can be handled in Lamination Theory without correspondence. Section 4.8 concludes.

4.2 The problem: Correspondence or Spreading

There are two predominant analyses of copy epenthesis: correspondence and spreading. In this section, I first describe the differences between these two analyses, and then briefly summarize an argument in favor of each one. I focus on two empirical areas, No Consonant Copying (Section 4.6) and prosodic identity (Section 4.7).

I'll use the Kolami copy epenthesis case to illustrate these two analyses here, repeated in (192) below. An epenthetic copy vowel is inserted between two consonants that are not followed by another vowel:

(192) Copy epenthesis in Kolami (Emeneau 1955: 88-90)

a.	/ajk/	aja̲k-t	'sweep-PST'	cf.	ajk-atun	'sweep-PRS'
b.	/erk/	ere̲k-t	'lit (fire)'		erk-ur	'light.fire-IMP'
c.	/sivk/	sivi̲k-tin	'became rotten'			
d.	/teḍp/	teḍe̲p	'cloth'		teḍp-ul	'cloths'
e.	/tupk/	tupu̲k	'gun'		tupk-ul	'guns'

The first analysis I call the "correspondence approach", which uses abstract correspondence relations to derive copy epenthesis (Kitto and de Lacy, 1999; Stanton and Zukoff, 2018). The first and second vowels correspond, and so they may be evaluated by IDENTITY constraints.

(193) HE-IDENT: 'The corresponding 'host' and 'epenthetic' vowels must be identical'

(194)

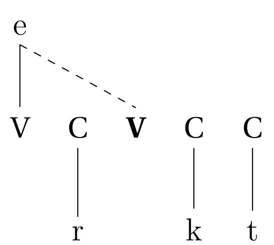
/erk-t/	*CCC	HE-IDENT	DEP-V
a. erk-t	*!		
☞ b. e_1re_1k-t			*
c. e_1ra_1k-t		*!	*

The correspondence approach is both straightforward and powerful. Stanton and Zukoff (2018) demonstrate that this pays off in what they call *prosodic identity* effects, where copying can be blocked in cases that would induce prosodic mismatches between the two correspondents.

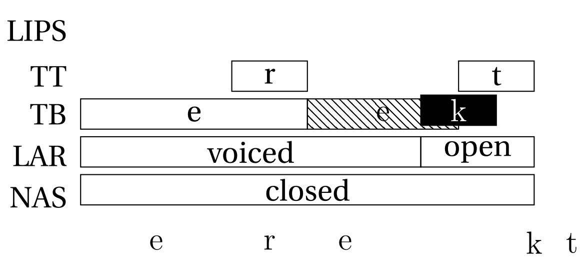
The main alternative to a correspondence approach is the "spreading" approach. Here I broadly group together analyses that use Autosegmental Spreading (Akinlabi, 1993; Bugenhagen et al., 1991; Kawahara, 2007) and gestural realignment (Hall, 2003). In both cases, the original vowel and copy are treated as a single unit that has been lengthened in time. I display an Autosegmental representation in (195a.) and a gestural one in (195b.)

(195) Spreading analysis of copy epenthesis using (a) autosegments or (b) gestures

a. Autosegmental Spreading (with tiers, e.g. Kawahara 2007)



b. Gestural lengthening (Hall, 2003; Steriade, 1990)



(196)

/erk-t/	*CCC	*FLOAT	*SPR	DEP-V
a. e V C C C r k t erkt	*!			
b. e V C **V** C C r k t erkat		*!		*
☞ c. e V C **V** C C r k t erek-t			*	*

While there are intuitive similarities between the spreading and correspondence analyses, they offer radically different predictions for phonological typology. In the spreading and gestural realignment analysis, copy epenthesis is lengthening of a single vowel. There is still just one gesture (or one feature bundle) present in the output.

In comparison, a correspondence-based analysis casts copy epenthesis as a consequence of abstract correspondence not so different from what is used in reduplication. There are two vowels present in the output, and while certain pressures may conspire to induce identity, additional mismatches may occur due to markedness.

The debate between spreading and correspondence analyses of copy epenthesis has thus far focused on two main kinds of evidence: the lack of consonant copy epenthesis and prosodic identity effects between original and host vowels. Spreading does not predict consonant copy epenthesis, which Kawahara (2007) presents as a reason to prefer spreading over correspondence. Correspondence, on the other hand, can easily handle prosodic identity effects, where suprasegmental features (like stress and length) also appear to copy. Stanton and Zukoff (2018) present several cases along these lines, and argue that correspondence readily accounts for prosodic identity, whereas spreading does not.

The takeaway here is that these two theories are different, and researchers disagree on where the gaps should be. Spreading predicts asymmetries between consonants and vowels, but also doesn't offer clear predictions for suprasegmentals. Correspondence predicts no asymmetries between consonants and vowels, but predicts suprasegmental features should copy as freely as anything else.

I now proceed onto another argument in favor of spreading based on sensitivity to segment quality. I observe that epenthesis almost always bears segmental restrictions, whereas partial reduplication often applies without reference to particular sounds. The typologies of copy epenthesis and partial reduplication are thus different, and uniform treatment of them (as under a correspondence-based approach) fails to account for the differences.

4.3 Typological survey of copy epenthesis

I conducted a typological survey that collected copy epenthesis patterns from Hall (2003); Kitto and de Lacy (1999); Odden (1991), and Kawahara (2007). Patterns were closely examined to determine (i) their generality, (ii) if they were phonologically invisible (to stress, allomorphy, reduplication), and (iii) if there were any segmental restrictions on their participation.

The survey covered 31 putative copy epenthesis patterns from 30 languages (17 language families). Some basic details are shown in (197) below. The full results are provided in Table 4.1.

(197) Summary of survey results on copy epenthesis

31 patterns from 30 languages, 17 language families	# patterns	# with segmental limitations
Language-general patterns	15	80% (12/15)
Metamorph patterns	6	33% (2/6)
Loanword-only	7	–
Unclear	3	67% (2/3)

The main observation is that a majority of the language-general patterns had some type of segmental restriction (see also Hall (2003): 80, Kawahara 2007: 20). Segmental restriction here is a cover term taken to mean that there is a restricted set of vowels that copy, or that there is a special set of consonants that are either transparent or block copying. For instance, in Chamicuro, copy epenthesis is segmentally restricted to only apply across a glottal stop, e.g. /japˈleʔti/ → [japˈleʔeti] 'lightning', /ˈtuʔlu/ → [ˈtuʔulu] 'chest' (Parker 1994: 266). Copy epenthesis across oral consonants in Chamicuro is not possible. Another kind of segmental restriction is found in Maga Rukai, where [a] cannot copy, but other vowels can (Hsin 2000: 104-109).

Out of the remaining three language-general patterns, they still had restrictions on the sounds involved, but these had more to do with the transitions between sounds. For example, in Welsh, copy epenthesis occurs in a heterorganic consonant cluster where the first consonant is a sonorant (e.g. /heːlm/ → [heːle̱m] 'cornstack', Awbery et al. 1984: 89). The restrictions in Welsh therefore appear to be slightly different than the cases in Chamicuro and Maga Rukai. In Chamicuro and Maga Rukai, the basic transparency or spreadability of the sounds is at stake, whereas in Welsh copy epenthesis has something to do with the transitions between sounds. If we set aside these internal differences, we are able to make a strong generalization: every language-general pattern had *some* kind of segmental restriction, even if they differ on whether that restriction is based on single sounds versus sounds-in-context.

In comparison, morphologically-restricted patterns often had no segmental restrictions whatsoever. Four out of six patterns copy any vowel across any intervening consonant. The two remaining patterns did have segmental restrictions, but they were a different type from those in the language-general patterns. In Makah and Lenakel, copy epenthesis follows a $V_\alpha C_1 C_2 \rightarrow V_\alpha C_1 V_\alpha C_2$ pattern, where there are restrictions on the C_2. In Makah, C_2 must be glottalized or voiced (Jacobsen, 1971; Werle, 2002). In Lenakel, C_2 must be /m/ (Lynch et al., 1978). I call this kind of segmental restriction 'endpoint sensitivity', because the restriction is not based on what vowels can copy or what consonants can intervene, but based on the consonant that follows the copy. There were only three examples of endpoint sensitivity in this survey: Makah, Lenakel, and Yapese. Endpoint sensitivity was never found in language-general patterns.

There were also two classes of patterns that were difficult to classify with respect to their generality. The first class was where there wasn't enough data one way or another to assess the generality of the pattern, as in Yapese, Iraqw, and Kolami. Kolami (Dravidian, Emeneau 1955) may come as a surprise given its prominent role in the copy epenthesis literature (e.g. Kawahara 2007), but almost all tokens of copy epenthesis occur with the past tense suffix [-t] (e.g. [ajak-t] 'sweep-PST' vs. [ajk-atun] 'sweep-PRS', (191a.)). While there are some nouns that also may display this pattern (e.g. [tupuk] 'gun' vs. [tupk-ul] 'guns', (191e.)), it's unclear if these should be analyzed as deletion or epenthesis. Yapese and Iraqw also had similar data problems, and so it was not possible to assess whether they were language-general or morphologically restricted.

The second class of patterns were those that only applied to loanwords. As an example, in Selayarese copy epenthesis occurs across loanword codas of [s, r, l] (Mithun and Basri, 1986). The reason why this pattern is hard to classify is because these codas only appear in loanwords in the lexicon. It's therefore impossible to tell whether the pattern is restricted to loanwords or if it would apply more widely if given the chance.

Patterns were also classified according to their phonological invisibility. If the outcome of stress assignment, reduplication, or allomorphy depended on the output of copy epenthesis, it was marked as visible. Conversely, if copy epenthesis was inert with respect to stress assignment, reduplication, or allomorphy it was marked as invisible. Patterns were there was no data one way or another were not classified either way.

The full survey data is provided in Table 4.1. Patterns that are either morphologically restricted or phonologically visible are highlighted in gray. Later on, I'll claim that these seven patterns must all occur in the metamorph layer. The remaining 24 can all be handled in the timing layer.

Table 4.1: Typological survey of copy epenthesis patterns. (Those argued to be metamorph layer patterns that use correspondence are highlighted in gray.)

Language	Pattern	Limits on participation	Morph.-restricted?	Phon. invisible?	Source
Arawakan					
Chamicuro	V_{α}ʔC → V_{α}ʔV_{α}C	Copying only across [ʔ]	✗	✓	Parker 1994: 266
Atlantic Congo					
Wolof	V_{α}CC → V_{α}CV_{α}C	none	✓	–	Ka 1994: 107-108
Yoruba	CrV_{α} → CV_{α}rV_{α}	Copying only across [r]. When C1 is [b] default [u] may appear	loanwords	–	Akinlabi 1993
Austronesian					
Budai Rukai	V_{α}C# → V_{α}CV_{α}#	only across [ŋ, l, s, r]; [a] cannot copy; blocked by j, w	✗	✓	Chen 2006: 215-217
Lenakel	V_{α}C-m… → V_{α}CV_{α}-m…	only verbs beginning with /m/	✓	–	Lynch et al. 1978: 17
Maga Rukai	V_{α}C# → V_{α}CV_{α}#	[a] cannot copy	✗	–	Hsin 2000: 104-109
Makassarese	V_{α}C# → V_{α}CV_{α}	Copying only when C is [r, l, s]	loanwords	✓	Aronoff et al. 1987
Mangap-Mbula	C-CV_{α}… → CV_{α}-CV_{α}…	none	✓	–	Bugenhagen et al. 1991: 57-58, 51-53
Maori, Cook Islands	VC# → VCV#	Copying only across [r]. If ir#, insert [a]. Otherwise insert [i].	loanwords	–	Kitto 1997, Kitto and de Lacy 1999: 6

Language	Pattern	Limits on participation	Morph.-restricted?	Phon. invisible?	Source
Marshallese	$\#CCV_\alpha \rightarrow \#CV_\alpha CV_\alpha$	[a] can only copy over [h]. All other vowels copy over oral consonants	✗	–	Bender 1968: 25, 33-34
Selayarese	$V_\alpha C\# \rightarrow V_\alpha CV_\alpha\#$	Copying is always across [s, l, r]	loanwords	✓	Mithun and Basri 1986
Yapese	$V_\alpha CC\# \rightarrow V_\alpha CV_\alpha C\#$	When C2 is dental or retroflex, insert fixed [o]. If there is a C3 that is [j], insert [i].	unclear	–	Jensen 1977: 88-90
Celtic					
Barra Gaelic	$V{:}CC\# \rightarrow V{:}_\alpha CV_\alpha C\#$	Consonant cluster must be heterorganic with sonorant C1, front/back vowels blocked over velarized/palatalized consonants	✗	–	Halle et al. 2000; Ní Chiosáin 1995; Stanton and Zukoff 2018
Welsh	$V{:}CC\# \rightarrow V{:}_\alpha CV_\alpha C\#$	Consonant cluster must be heterorganic with sonorant C2	✗	–	Awbery et al. 1984: 88-90
Cushitic					
Iraqw	$VCC\# \rightarrow V_\alpha CV_\alpha C\#$	[u] copies across velars and gutturals, [i, a] only copies across gutturals	unclear	–	Rose 1996: 77
Dravidian					
Kolami	$VCC \rightarrow V_\alpha CV_\alpha$	none	unclear	✗	Emeneau 1955: 80
Indo-European					

Language	Pattern	Limits on participation	Morph.-restricted?	Phon. invisible?	Source
Farsi	$V \rightarrow CV_{\alpha}RV_{\alpha}$	Copying only across [r] and [l]	loanwords	–	Jam 2020
Finnish	$VCC \rightarrow V_{\alpha}CV_{\alpha}C$	Vowel must be stressed, cluster must be heterorganic and C1 must be voiced	✗	✓	Hall (2003); Karlin (2022)
Sranan	$V_{\alpha}C\# \rightarrow V_{\alpha}CV_{\alpha}\#$	[a] cannot copy, instead quality determined by surrounding consonants	loanwords	–	Uffmann 2006: 1090
Iroquoian					
Mohawk	$CʔV_{\alpha} \rightarrow CV_{\alpha}ʔV_{\alpha}\#$	Copying only across [ʔ]	✗	✓	Postal 1969
Japonic					
Japanese	$V_{\alpha}h\# \rightarrow V_{\alpha}hːV_{\alpha}\#$	Copying only across [h]	✗	–	Kawahara 2007
Jê					
Kĩsêdjê	$V_{\alpha}C\#_{utt} \rightarrow V_{\alpha}CV_{\alpha}\#_{utt}$	[a] cannot copy, no copying across [ɲ] or [ir], oral vowels cannot copy across nasals	✗	✓	Nonato 2014: 128-130
Mande					
Mahou (Mawu)	$CrV_{\alpha} \rightarrow CV_{\alpha}rV_{\alpha}$	Copying only across [r], default [i/u] occurs in ClV clusters	loanwords	–	Kenstowicz 2003: 99-100
Mayan					
Kekchi	$V_{\alpha}ʔC \rightarrow V_{\alpha}ʔV_{\alpha}C$	Copying only across [ʔ]	✗	✓	Campbell 1974; Hall 2003
Niger-Congo					
Mono	$CrV_{\alpha} \rightarrow CV_{\alpha}rV_{\alpha}$	Copying only across [r]	✗	✓	Hall 2003; Olson 2003: 84-85

Language	Pattern	Limits on participation	Morph.-restricted?	Phon. invisible?	Source
Mono	$CV_\alpha(C)\# \rightarrow V_\alpha CV_\alpha(C)\#$	none, see Section 4.4.3	✓	✗	Hall 2003; Olson 2003: 84-85
Salishan					
Klamath	$C\text{-}CV_\alpha \ldots \rightarrow CV_\alpha\text{-}CV_\alpha \ldots$	none	✓	–	Barker 1963, 1964; Odden 1991
Semitic					
Arabic, Bedouin	aHC... → aHaC	An [a] copies across a guttural consonant	✗	–	McCarthy 1984a: 213
Hebrew, Ancient	aHC... → aHaC	An [a] copies across a guttural consonant	✗	–	McCarthy 1984a: 214
Tucanoan					
Desano	$V[ʔ/h]C \rightarrow V_\alpha[ʔ/h]V_\alpha C$	Copying only across [ʔ, h]	✗	–	Miller 1999: 12, de Lima Silva 2012: 46-54
Wakashan-Tsimshanic					
Makah	$\ldots VC\text{-}C\ldots \rightarrow \ldots V_\alpha CV{:}_\alpha\text{-}C\ldots$	The C2 must be glottalized or voiced. Only applies to monosyllabic stems	✓	–	Jacobsen 1971; Werle 2002

The typology of copy epenthesis also bears some similarities to metathesis in Chapter 3. In languages where the set of transparent consonants is restricted, transparent consonants tend to be sonorants, as in (198). Laryngeals are the most common, followed by liquids. Other languages are freer on what they copy across, and include stridents, other sonorants like nasals, and voiced consonants.

(198) Transparent consonants tend to be sonorants

Transparent consonants	Count	Languages
Laryngeals (and gutturals)	8	Chamicuro, Marshallese (for [a]), Mohawk, Japanese, Kekchi, Bedouin Arabic, Ancient Hebrew, Desano
Liquids	5	Yoruba, Cook Islands Maori, Farsi, Mahou (Mawu), Mono
Nasals, liquids, stridents	3	Budai Rukai, Makassarese, Selayarese
Sonorants	2	Barra Gaelic, Welsh
Voiced Cs	1	Finnish

Additionally, several languages placed restrictions on which vowels can copy, as in (199). Notably, all these cases concerned [a]. In Maga Rukai, Marshallese, Sranan, and Kĩsêdjê, [a] cannot copy (a default epenthetic vowel is inserted instead). This is reminiscent of restrictions on metathesis in Meto (Section 3.4.1), where all vowels other than [a] can metathesize. Conversely, in Bedouin Arabic and Ancient Hebrew, only [a] can copy across guttural consonants, other vowels cannot.

	Non-participating vowels		
(199)	[a]	4	Maga Rukai, Marshallese (only copies over [h]), Sranan, Kĩsêdjê
	Everything but [a]	2	Bedouin Arabic, Ancient Hebrew

To summarize, the typology of copy epenthesis is rich with segmental restrictions. Very few languages copy any kind of vowel across any kind of consonant, and even in the few that do (e.g. Kolami, Klamath, etc.), these patterns tend to bear morphological restrictions or hallmarks of phonological visibility that the more general patterns lack.

In the next section, I argue that there are two kinds of copy epenthesis. There is copy epenthesis that occurs via spreading, and then there is copy epenthesis that occurs via surface correspondence. I argue that this split typology of copy epenthesis is evidence in favor of assuming a bifurcated model of phonology: the timing layer can only spread, but the metamorph layer can create and evaluate long-distance correspondence relations that resemble true copying.

There are six generalizations and asymmetries to explain, summarized in (200):

(200) Two kinds of copy epenthesis

	Language-general	Morphologically-restricted
Target of copying restricted?	✓	✗
Transparent segments restricted?	✓	✗
Endpoint restrictions?	✗	✓
Visible to stress/reduplication?	✗	✓
Visible to allomorphy?	✗	✓
Can copy non-locally?	✗	✓

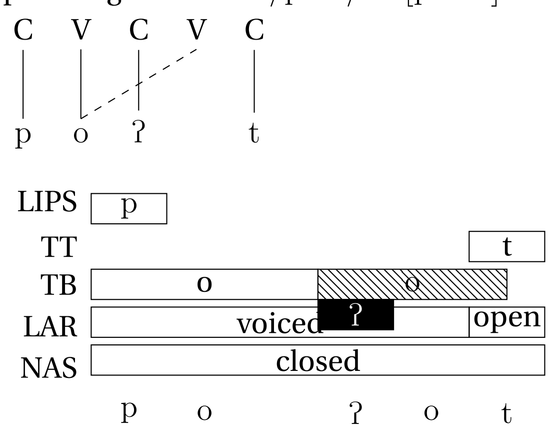
4.4 Analysis

In this section, I claim that the mechanisms responsible for copy epenthesis in general versus. morphologically-restricted patterns are different. Language-general copy epenthesis takes place through the same mechanism as metathesis, where sounds spread in the timing layer. Morphologically-restricted copy epenthesis, on the other hand, is essentially a kind of reduplication where segments correspond in the metamorph layer.

4.4.1 Language-restricted copy epenthesis: spreading

I propose that language-general copy epenthesis occurs in the timing layer, and takes place by spreading.

(201) Spreading for Kekchi /poʔt/ → [poʔot] 'huipil (blouse)' (Hall 2003: 81)



Spreading in the timing layer is constrained by *the Rule of Most Specified* (which is a hard restriction on GEN) and constraint hierarchies on multiple association (see Chapter 2). I claim that *LINECROSS and *SPAWN use the same feature-counting mechanism as *the Rule of Most Specified*: the more features a segment has, the easier it is for it to overlap other sounds and spread. These constraint hierarchies are violable, but the prediction is that once segments have the same number of features, line-crossing is fully eliminated by a restriction on GEN (*the Rule of Most Specified*).

(202) *LINECROSS: ‘No crossing association lines’

For each pair of association lines that cross, assign one violation.

(203) *SPAWN: ‘Segments should be associated with just one slot’

For a segment x that is associated with a slot C_i/V_i, assign one violation for each additional slot C_j/V_j that is also associated with x.

We can then relativize *LINECROSS and *SPAWN for certain consonant qualities, e.g. *LINECROSS[VOWEL]: ‘Don’t cross association lines when one of the associated segments is a vowel’. We then use the same hierarchy as in Chapter 3 for *MULTIPLE, but apply it here to *SPAWN and *LINECROSS.

(204) *LNCROSS[OBS] ≫ *LNCROSS[LAB] ≫ *LNCROSS[NAS] ≫ *LNCROSS[STR], *LNCROSS[LIQ] ≫ *LNCROSS[GLIDE], *LNCROSS[LARYNGEAL] ≫ *LNCROSS[VOWEL]

(205) *SPAWN[OBS] ≫ *SPAWN[LAB] ≫ *SPAWN[NAS] ≫ *SPAWN[STR], *SPAWN[LIQ] ≫ *SPAWN[GLIDE], *SPAWN[LARYNGEAL] ≫ *SPAWN[VOWEL]

I claim that these feature-counting hierarchies are confined to the timing layer, and so we only expect for this hierarchy to be used for timing layer effects.

In the typology of copy epenthesis, we expect different languages to differ on where they allow domination of *LINECROSS. All languages with copy epenthesis have dominated *LNCROSS[VWL] and *SPAWN[VOWEL], but they differ on whether they allow copying across all consonants (violating *LNCROSS[OBS] and those below) or if they only restrict copying across certain sonorants (violating *LNCROSS[LIQ] and everything below).

The predicted typology of copy epenthesis patterns thus resembles (206):

(206) Predicted typology of copy epenthesis

less specified, harder to cross | *more specified, easier to cross*

✓obstruents	_nasals	_stridents	_liquids	_laryngeals	_glides	Kĩsêdjê
_obstruents	✓nasals	_stridents	_liquids	_laryngeals	_glides	Welsh
_obstruents	_nasals	✓stridents	_liquids	_laryngeals	_glides	Selayarese
_obstruents	_nasals	_stridents	✓liquids	_laryngeals	_glides	Fongbe
_obstruents	_nasals	_stridents	_liquids	✓laryngeals	_glides	Desano
_obstruents	_nasals	_stridents	_liquids	_laryngeals	✓glides	*unattested?*

One kind of pattern that is predicted under this approach, but not yet attested, is one where copy epenthesis only occurs across glides. The reason for this gap follows from *the Rule of Most Specified*. While it is easier to spread across more specified sounds, the absolute requirement is that one sound must still be more specified than the sound it crosses over, otherwise we obtain a linearization failure. Glides are arguably featurally identical to vowels, and so a language with copy epenthesis only across glides would need two things to be true: glides must be similar enough to vowels to be ranked low in the hierarchy, but they must be different enough such that vowel-glide spreading isn't fully ruled out. These two requirements pull in opposite directions, and so languages like this are expected to be rare.

It's also worth noting that this typology of copy epenthesis closely resembles the typology of blockers in nasal harmony (Walker, 1999) and the typology of blockers in metathesis (Chapter 3). More specified sounds (= more sonorous sounds) are more permeable, those that are less specified are less permeable (see also Grammont 1933; Hall 2003).

To summarize, copy epenthesis is expected to occur when three factors are aligned. First, one feature bundle must be more specified than another. This is an absolute restriction, and cannot be avoided. Second, *LINECROSS must be ranked low enough to permit spreading across certain consonants. Third, *SPAWN-C/V must be dominated, allowing segments to associate with multiple slots. Languages with local assimilation satisfy just this third requirement, those with epenthesis satisfy the second, and those with copy epenthesis satisfy all three.

4.4.2 Morphologically-restricted copy epenthesis: Correspondence

In comparison, I claim morphologically-restricted copy epenthesis takes place through correspondence (following Kitto and de Lacy, 1999; Stanton and Zukoff, 2018). The host (or base) segment and the epenthetic segment stand in a surface correspondence relation. Identity is then driven by constraints over that correspondence relation, such as HE-IDENT[F]:

(207) HE-IDENT[F]: Assign one violation mark for each pair of vowels standing in HE correspondence that do not have identical values for [F]. (Stanton and Zukoff 2018: 640)

There are no limits on the kinds of segmental qualities that can be copied in the correspondence approach. As long as a segment is present, it can be copied, just as in reduplication.

However, I claim that these kinds of surface correspondence relations are unique to the metamorph layer — they can only be made between segments or between syllables, never between timing layer slots. The only way to copy in the timing layer is to spread, and the only way to copy in the metamorph layer is to correspond.

The assumption that each layer is restricted in how to obtain identity derives four facts. First, partial copying is expected to be more common in morphologically-restricted patterns (e.g. copying height or place), since identity is driven by separate HE-IDENT[F] constraints. In comparison, partial copying in the timing layer should be rare (if it occurs at all), since it would require a segment to spread and then additional features to be inserted that obscure the original value. Second, long-distance copying of consonants should be possible in morphologically-restricted patterns, but not in general ones (see Section 4.6). Third, blocking should be rare (if attested at all) in timing layer patterns, as it would have to be motivated by independent markedness constraints (e.g. trigram *ɔjɔ in Fongbe, Section 4.5.1) or by other constraints that force surface correspondence to be strictly local in some languages (Bennett, 2015; Rose and Walker, 2004). Fourth, transparency should differ between the two layers. The timing layer uses feature-counting based hierarchies, but the metamorph layer does not. We therefore expect metamorph-layer patterns to show greater variability on the kinds of transparent segments they allow.

4.4.3 Sample derivations: Mono Copy Epenthesis

Hall (2003) examines copy epenthesis in Mono, a Niger-Congo language spoken in Congo (Olson, 2003; Olson and Schrag, 1997), and observes that there are two kinds of copy epenthesis. There is copy epenthesis that occurs in consonant clusters, which is phonologically invisible and occurs via gestural intrusion, and then there is copy epenthesis for word minimality, which appears to insert an abstract syllable.

In this section, I review the evidence from Mono, and concur with Hall (2003)'s conclusion: there must be two kinds of copy epenthesis. I cast my analysis in Lamination Theory, using the timing layer to derive copy epenthesis in consonant clusters, and the metamorph layer to derive copy epenthesis as a word minimality effect.

I begin with the word minimality cases. In Mono, monosyllabic words gain an epenthetic vowel that copies the quality and tone of the root vowel, shown in (208). Note that in these examples, the vowels are copied across all sorts of consonants, including oral stops, which in my theory is a diagnostic of metamorph epenthesis. When these same roots appear in compounds or affixed verbal forms, the epenthetic vowel disappears because the words are no longer monosyllabic (Hall 2003: 84). Another detail about this pattern is that it can be non-local. In (208i.-j.), the more sonorous vowel copies (e.g /ge̯à/ → à̱le̯à 'animal'), not the first vowel in the VV sequence (*ḕle̯à). Hall (2003) describes these as "true epenthetic vowels", which in my theory are epenthetic vowel segments in the metamorph layer.

(208) Mono: minimality-driven copy epenthesis in monosyllables (Olson 2003, via Hall 2003:

84)

Local copying of root vowel

a.	/ʒī/	ī̱ʒī	'tooth'
b.	/dɨ̀/	ɨ̱̀dɨ̀	'horn'
c.	/ngú/	ú̱ngu	'water'
d.	/bè/	è̱bè	'liver'
e.	/rə̀/	ə̱̀rə̀	'thing'
f.	/gò/	ò̱gò	'hunger'
g.	/mà/	à̱mà	'mouth'
h.	/lɔ̀/	ɔ̱̀lɔ̀	'sun'

Non-local copying of most sonorous vowel

i.	/ge̯à/	à̱le̯à	'animal'
j.	/ko̯à/	à̱ko̯à	'work'

Mono also has copy epenthesis in consonant-liquid clusters, as in (209). While minimality-driven copy epenthesis and liquid cluster copy epenthesis patterns appear similar on the surface, they differ in a number of other respects: (i) the liquid cluster pattern is segmentally restricted, whereas the minimality-driven pattern is segmentally blind, (ii) the liquid cluster pattern is optional in casual speech, and (iii) they differ on their phonological visibility. These are all hallmarks of timing layer epenthesis in my theory.

(209) Mono copy epenthesis in liquid clusters (Olson 2003, via Hall 2003: 84)

a.	/gàfrū/	gàfū̱rū	'mortar'
b.	/pléz=u/	pé̱léz=u	'bat'
c.	/jābrù/	jābù̱rù	'goat'
d.	/dɔ́klɔ́ngbā/	dɔ́kɔ̱́lɔ́ngbā	'scorpion'

The liquid cluster pattern is phonologically invisible with respect to the minimality-driven copy epenthesis pattern. In monosyllabic words that begin with a obstruent-liquid cluster, minimality-driven copy epenthesis still applies, even though liquid copy epenthesis appears as if it should be enough to bring words up to a disyllabic minimum. Hall (2003) concludes from these data that liquid cluster epenthesis is gestural intrusion, which in my analysis is spreading in the timing layer.

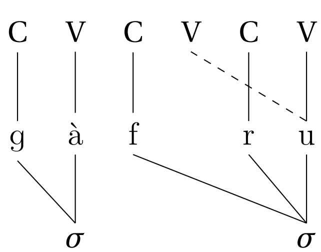
(210) Monosyllabic epenthesis applies in CR words (Olson 2003, via Hall 2003: 85)

a.	/ʃrí/	í̠ʃí̠rí	‘shadow’
b.	/ʔrɨ̄/	ɨ̠̄ʔɨ̠̄rɨ̄	‘name’
c.	/k͡plú/	ú̠k͡pú̠lú	‘heap’
d.	/gré/	é̠gé̠ré	‘big, large’
e.	/brə́/	ə̠́bə̠́rə́	‘quarrel’
f.	/prō/	ō̠pō̠rō	‘egg’
g.	/g͡brà/	à̠g͡bà̠rà	‘bridge’
f.	/krɔ̄/	ɔ̠̄kɔ̠̄rɔ̄	‘skull’

In Lamination Theory, I frame Hall’s analysis in representational terms. Liquid cluster epenthesis is spreading in the timing layer (211a.), whereas minimality-driven copy epenthesis is copying of a syllable in the metamorph layer (211b.).

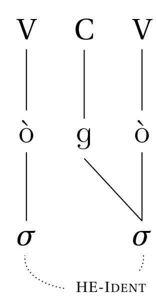
(211)

a. Liquid cluster copy epenthesis



gàfū̠rū ‘mortar’ (209a.)

b. Monosyllabic copy epenthesis

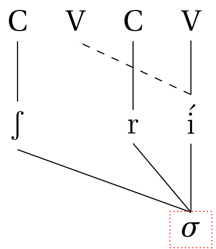


ògò ‘hunger’ (208f.)

The “invisibility” of liquid cluster copy epenthesis follows from the difference in representation. Liquid cluster epenthesis on its own does not create a new syllable (212a.) and so minimality-driven epenthesis is still forced to apply (212b.).

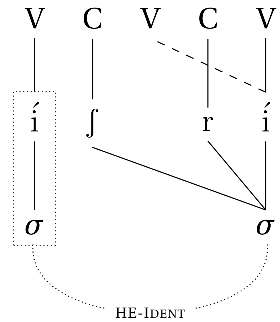
(212)

a. No new syllable with liquid cluster epenthesis



✗ *ʃí̠rí

b. Minimality-driven epenthesis must apply



✓ í̠ʃí̠rí 'shadow' (210a.)

The two kinds of copy epenthesis in Mono thus line up with the representational differences between the timing and metamorph layers. Word minimality epenthesis, which is restricted to roots, has no sensitivity to intervening sounds and is blind to general effects. In comparison, liquid cluster copy epenthesis is general, sensitive to speech rate, and is blocked across non-liquids. (See the Appendix for a version of this analysis using constraints.)

The Mono pattern also offers us clues on how the timing and metamorph layers must interact. Why does the derivation produce [iʃiri] instead of [ʃiri], killing two birds with one stone? If the layers are serial, where the metamorph layer evaluation precedes the timing layer, then the facts in (212) are simple to describe. The reason why we get [iʃiri] and not *[ʃiri] is because there is no derivational look-ahead. In a parallel model, the same question is trickier to answer because *[ʃiri] (with a copied segment) should harmonically bound [iʃiri]. The way around this is to contend that metamorph copy-epenthesis has an anti-infixation requirement in Fongbe (e.g. CONTIGUITY), and that this dominates timing layer *SPAWN and *LINECROSS. I now proceed to case studies that demonstrate how spreading derives blocking effects.

4.5 Case Studies: Blocking in copy epenthesis

According to Lamination Theory, the typology of blocking in copy epenthesis should follow from how *SPREAD interacts with the *Rule of Most Specified.* In an absolute sense, when a vowel is more specified than a consonant, it can cross over it, but when they are similarly specific (or the vowel is less so), then copying should be blocked. Spreading should likewise be favored for more specified segments over less-specified ones. In this section, I present two case studies along these lines: blocking of copy-epenthesis by glides in Fongbe (Lefebvre and Brousseau, 2002), and oral-nasal blocking in Kĩsêdjê (Nonato, 2014).

4.5.1 Fongbe: Glide blocking

In Fongbe, consonant clusters may be broken apart by inserting an optional epenthetic vowel (Lefebvre and Brousseau 2002: 19). The quality of the epenthetic vowel is dependent on the kind of consonant cluster. In Cl clusters, the inserted vowel is a copy vowel, as in (213a.). In Cj clusters, the inserted vowel is fixed as [i], shown in (213b.).

(213) Fongbe: copy epenthesis across [l] but not [j] (Lefebvre and Brousseau 2002: 19)

a.	ClV	klɔ́	∼ kɔ́lɔ́	'to wash'
		wlí	∼ wílí	'to catch'
		x͡wlɛ́	∼ x͡wɛ́lɛ́	'to peel'
		hlà	∼ hàlà	'hyena'
		hlɔ́	∼ hɔ́lɔ́	'to make'
b.	CjV	bjɔ́	∼ bíjɔ́	'to ask'
		fjɔ́n	∼ fíjɔ́n	'to twist'
		ljá	∼ líjá	'to climb'

Note that the tone of the vowel is predictable — it is always the same as the original vowel.

These Cl and Cj clusters are the only onset clusters in Fongbe (Lefebvre and Brousseau, 2002). The inventory of Fongbe consonants and vowels is given in (214) below.

(214) Inventory of Fongbe consonants and vowels (based off of Lefebvre and Brousseau 2002: 16)

	PLACE	VOI	CONS	SON	NAS	CONT	LAT	STR	ANT	HI	FR	RD	ATR	# feat.
w	LAB, DOR	+	+	+	0	+	0	0	0	0	0	+	0	5
b	LAB	+	+	-	0	-	0	0	0	0	0	+	0	5
f	LAB	-	+	-	0	+	0	0	0	0	0	+	0	5
v	LAB	+	+	-	0	+	0	0	0	0	0	+	0	5
t	COR	-	+	-	0	-	0	0	-	0	0	0	0	5
d	COR	+	+	-	0	-	0	0	-	0	0	0	0	5
ɖ	COR	+	+	-	0	-	0	0	+	0	0	0	0	5
c	DOR	-	+	-	0	-	0	0	0	+	0	0	0	5
ɟ	DOR	-	+	-	0	-	0	0	0	+	0	0	0	5
k	DOR	-	+	-	0	-	0	0	0	0	0	0	0	4
g	DOR	+	+	-	0	-	0	0	0	0	0	0	0	4
x	DOR	-	+	-	0	+	0	0	0	0	0	0	0	4
ɣ	DOR	+	+	-	0	+	0	0	0	0	0	0	0	4
k͡p	DOR, LAB	-	+	-	0	-	0	0	0	0	0	+	0	5
g͡b	DOR, LAB	+	+	-	0	-	0	0	0	0	0	+	0	5
x͡w	DOR, LAB	-	+	-	0	+	0	0	0	0	0	+	0	5
ɣ͡w	DOR, LAB	+	+	-	0	+	0	0	0	0	0	+	0	5
m	LAB	+	+	+	+	-	0	0	0	0	0	0	0	5
n	COR	+	+	+	+	-	0	0	-	0	0	0	0	6
l	COR	+	+	+	0	+	+	0	-	0	0	0	0	6
s	COR	-	+	-	0	+	0	+	-	0	0	0	0	6
z	COR	+	+	-	0	+	0	+	-	0	0	0	0	6
j	DOR	+	+	+	0	+	0	0	0	+	+	-	+	8
i	DOR	+	-	+	0	+	0	0	0	+	+	-	+	8
e	DOR	+	-	+	0	+	0	0	0	-	+	-	+	8
ɛ	DOR	+	-	+	0	+	0	0	0	-	+	-	-	8
a	DOR	+	-	+	0	+	0	0	0	-	-	-	-	8
ɔ	DOR	+	-	+	0	+	0	0	0	-	-	+	-	8
o	DOR	+	-	+	0	+	0	0	0	-	-	+	+	8
u	DOR	+	-	+	0	+	0	0	0	+	-	+	+	8

I analyze Fongbe consonant epenthesis in terms of spreading. The intuition is that Fongbe consonant epenthesis is metathesis-like displacement of a vowel. Only spreading across sonorants is possible, but when the sonorant is too vowel-like, spreading is ruled out by the hard restriction on GEN I called *The Rule of Most Specified.* In these blocked cases, the quality of the epenthetic vowel must come from a different source. I introduce four constraints, *CC#, DEP-V, *SPAWN[VOWEL], and *LINECROSS.

(215) *#CC: Assign a violation for any word that begins with two C-slots.

(216) Dep[F]: Assign a violation for a feature in the output that has no correspondent in the input.

(217) *Spawn[Vowel]: ‘Vowels are associated with only one slot’

For a [+syll] segment x associated with a slot C_i/V_i, assign a violation for each slot C_j/V_j that is also associated with x.

(218) *LineCross: ‘Association lines do not cross’

Assign a violation for each pair of association lines that cross.

In [Cl] clusters, spreading will be preferred to default epenthesis (Dep[F] ≫ *Spawn[Vowel], *LineCross). I also assume undominated HavePlace (Padgett, 1995), and so featureless V-slots are likewise ruled out.

(219) Copy epenthesis across laterals: /klɔ́/ → [kɔ́lɔ́] ‘to wash’

/klɔ́/	*#CC	Dep[F]	*Spawn[Vowel]	*LineCross
a. C C V / k l ɔ́ [klɔ́]	*!			
☞ b. C V C V / k l ɔ́ [kɔ́lɔ́]			*	*
c. C V C V / k [+hi] l ɔ́ [kilɔ́]		*!		

By contrast, spreading is not possible in [Cj] clusters due to the *Rule of Most Specified.* Spreading here would require the vowel to cross over the glide, but this is would cause a linearization failure: the glide and vowel have the same number of features (see (214), they both have 8), and so neither can contain the other. Timing GEN therefore does not create this candidate, and so the derivation is forced to select the next-best option: spreading from the glide itself.

(220) Default epenthesis across glides: /bjɔ/ → [bíjɔ́] 'to ask' (213b.)

/klɔ́/	*#CC	DEP[F]	*SPAWN[GLIDE]	*SPAWN[VOWEL]
a. C C V / b j ɔ́ [bjɔ́]	*!			
☞ b. C V C V / b j ɔ́ [bíjɔ́]			*	
d. C V C V / b [+HI] j ɔ́ [bijɔ́]		*!		

An alternate analysis here is that DEP[F] is dominated, and that candidate d. wins. However, in this case, we would still need to explain why the tone matches between copy vowel and host. Under this analysis, this can be explained as long as we allow tone to be included inside the vowel feature bundle.[37]

We may wonder what happens in clusters that consist of a glide and lateral, since they are equal in terms of *MULT[GLIDE] versus *MULT[VOWEL] violations. In this case, copying from the vowel (rather than the glide) still applies:

(221) Glide-lateral clusters: copying occurs from the vowel

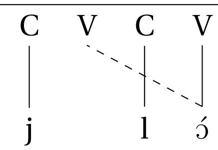
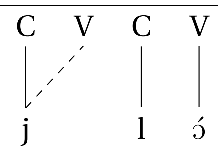
[jlɔ́] ∼ jɔ́lɔ́ 'to call' *jilɔ́

[37] Whether or not tone counts for the *Rule of Most Specified* is up for debate. Both possibilities can be made to work. For instance, if tone counts, then we could say that vowels are underspecified for [±CONT]. If tone doesn't count, like PLACE, then we can keep the feature system as it is in (214).

I capture this pattern with a markedness constraint that penalizes consonants mapped to V-slots, *CTOV. *CTOV is dominated by DEP[F] in (220) above, but it also dominates *SPAWN[GLIDE]. Whenever possible, vowels will spread to form epenthetic vowels.

(222) *CTOV: Assign a violation for a [+CONS] feature bundle associated with a V-slot.

(223) Derivation of /jlɔ́/ → [jɔ́lɔ́] 'to call'

/jlɔ́/	*CTOV	*SPAWN[GLIDE]	*SPAWN[VOWEL]
☞ a.  [jɔ́lɔ́]			*
b.  [jílɔ́]	*!	*	

In a correspondence analysis, the above facts could also be analyzed as an effect of the Emergence of the Unmarked (McCarthy and Prince, 1994). For instance, we could say that any vowel-glide sequence other than [ij] is marked (cover constraint: *¬ij). Epenthesis will therefore copy in any environment other than a Cj cluster.

(224)

/bjɔ́/	*#CC	*¬ij	HE-IDENT	DEP
a. bjɔ́	*!			
b. bɔ́$_1$jɔ́$_1$		*!		*
☞ c. bí$_1$jɔ́$_1$			*	*

While Fongbe can be analyzed in terms of either spreading or correspondence, the existence of cases like Fongbe is critical for a spreading analysis. Glides are the most similar segments to vowels, and so if *The Rule of Most Specified* is right, I predict cases like Fongbe to be quite common.

4.5.2 Kĩsêdjê: Nasal and Oral Consonant Blocking

Kĩsêdjê (Macro-Je, Beauchamp 2019; Nonato 2014) has copy epenthesis that is sensitive to nasality. In consonant-final utterances, oral vowels can spread across oral consonants (225), and nasal vowels can spread across nasal consonants (226). (For the purposes of this section, I won't be discussing the intervocalic lenition pattern in the obstruents.)

(225) Kĩsêdjê: Oral vowels copy across oral consonants (Beauchamp, 2019; Nonato, 2014)

	phrase-final		phrase-medial
a. /rop/	ˈrowo̲	'jaguar'	rop
b. /tʰɛp/	ˈtʰɛwɛ̲	'fish'	tʰɛp
c. /mɨt/	ˈmbɨɾɨ̲	'sun'	mɨt
d. /mɘr/	ˈmbɘrɘ̲	'to cry'	mɘr
e. /ɲɜt/	ˈɲjɜɾɜ̲	'potato'	ɲɜt
f. /ŋɹot/	ˈŋgɹoɾo̲	'the Pleiades'	

(226) Kĩsêdjê: Nasal vowels copy across nasal consonants (Nonato, 2014)

	phrase-final		phrase-medial
a. /pãm/	ˈpãmã̲	'father'	pãm
b. /hrɔ̃n/	ˈhrɔ̃nɔ̲̃	'to run'	hrɔ̃n
c. /tũn/	ˈtũnũ̲	'to argue'	
e. /kʰɛ̃n/	ˈkʰɛ̃nɛ̲̃	'rock'	
f. /sumkʰɹɛɲkʰɔ̃n/	sumkʰɹɛɲˈkʰɔ̃nɔ̲̃	'ear'	

However, oral consonants cannot spread across nasals (227), and so we see default epenthesis of [i/ɨ] in those positions.

(227) Oral vowels do not copy across nasals (Nonato, 2014)

a. /mɜn/	mbɜni	‘red arara’	*mbɜnɜ	cf. (225)
b. /mɛn/	mbɛni	‘honey’	*mbɛnɛ	
c. /nton/	ntoni	‘a proper name’	*ntono	
d. /h^{w}ɨsɨsom/	h^{w}ɨsɨsomɨ	‘mosquito’	*h^{w}ɨsɨsomo	
e. /ɲun/	ɲjuni	‘hummingbird’	*ɲjunu	

The restriction on oral-nasal spreading is not symmetric. Nasal vowels are able to spread over [r] despite it not being nasal, as in (228).

(228) Nasal vowels can copy over the oral consonant [r] (Nonato, 2014)

a. /ŋɔ̃r/ ˈŋɔ̃rɔ̲̃ ‘to sleep’

Nasalized vowels in Kiseje can only be followed by sonorants, and so there is no evidence either way on whether nasals can spread over other oral consonants such as /p t k/.

Additionally, vowel copying is always blocked when (i) the final vowel is [a] (229) or (ii) when the intervening consonant is a palatal nasal /ɲ/ (230).

(229) Copy epenthesis is blocked when the final vowel is [a] (Nonato, 2014)

	phrase-final			
a. /k^{h}rat/	k^{h}ɹaɾi	‘beginning’	*k^{h}raɾa	cf. (225a.)
b. /t^{h}ak/	t^{h}akɨ̲	‘to open’	*t^{h}aka	

(230) Copy epenthesis blocked when intervening consonant is [ɲ] (Nonato, 2014)

a. /pəɲ/	pəji̲	‘to arrive’	*pəjə
/nihaɲ/	nihaji̲	‘there’	*nihaja
b. /sariɲ/	sarija̲	‘to hang (plural)’	*sariji
/ak^{h}iɲ/	ak^{h}ija̲	‘to shout’	*ak^{h}iji
/kuk^{h}iɲ/	kuk^{h}ija̲	‘to ask’	*kuk^{h}iji

Note that there is a vowel dissimilation pattern happening here: after [iɲ] sequences the epenthetic vowel is [a] (230b.), whereas after stem-final [a] or other [Vɲ] sequences (229)-(230a.), the epenthetic vowel is [i].

A last observation is that stress is generally word-final in Kĩsêdjê (Nonato 2014: 130), but words with epenthesis all have penultimate stress. The epenthesized vowel never bears stress. Cross-linguistically,this is a common phenomenon, and there is a significant literature dedicated to explaining these kinds of stress-epenthesis interactions (Alderete et al., 1999; Broselow, 1982; Elfner, 2009; Hall, 2003; Itô, 1989; Stanton and Zukoff, 2018). I set aside the Kĩsêdjê stress pattern for now, and focus on analyzing the segmental facts.

I provide the Kĩsêdjê inventory in (231) below. Unlike other languages discussed so far in this thesis, the Kiseje inventory is skewed heavily towards vowel contrasts (20 vowels, 14 consonants). Here I assume palatals are [+HIGH] dorsal consonants, which later on will be used for deriving the vowel dissimilation facts. I also assume that high vowels have a coronal feature, and that round vowels have a labial feature.

(231) Inventory of Kĩsêdjê consonants and vowels (based off of Nonato 2014: 125)

	Place	s.g.	Cons	Son	Nas	Cont	Str	Hi	Fr	Rd	ATR	# feat.
w	Lab, Dor	0	+	+	0	+	0	0	0	0	0	3
b	Lab	-	+	-	0	-	0	0	0	0	0	4
t	Cor	+	+	-	0	-	0	0	0	0	0	4
d	Cor	-	+	-	0	-	0	0	0	0	0	4
k	Dor	+	+	-	0	-	0	0	0	0	0	4
g	Dor	-	+	-	0	-	0	0	0	0	0	4
r	Cor	0	+	+	0	+	0	0	0	0	0	4
h	Lar	+	+	-	0	+	0	0	0	0	0	4
s	Cor	+	+	-	0	+	+	0	0	0	0	5
tʃ	Dor	+	+	-	0	-	(+)	+	0	0	0	5
j	Dor	0	+	+	0	+	0	+	0	0	0	5
m	Lab	0	+	+	+	-	0	-	0	0	0	5
n	Cor	0	+	+	+	-	0	-	0	0	0	5
ŋ	Dor	0	+	+	+	-	0	-	0	0	0	5
ɲ	Dor	0	+	+	+	-	0	+	0	0	0	6
i	Dor, Cor	0	-	0	0	0	0	+	+	-	+	5
ɨ	Dor	0	-	0	0	0	0	+	-	-	+	5
u	Dor, Lab	0	-	0	0	0	0	+	-	+	+	5
e	Dor, Cor	0	-	0	0	0	0	-	+	-	+	5
ɘ	Dor	0	-	0	0	0	0	-	-	-	+	5
o	Dor, Lab	0	-	0	0	0	0	-	-	+	+	5
ɛ	Dor, Cor	0	-	0	0	0	0	-	+	-	-	5
ɜ	Dor	0	-	0	0	0	0	-	-	-	-	5
ɔ	Dor, Lab	0	-	0	0	0	0	-	-	+	-	5
a	Dor	0	-	0	0	0	0	+	-	-	-	5
ĩ	Dor, Cor	0	-	0	0	0	0	+	+	-	+	6
ɨ̃	Dor	0	-	0	+	0	0	+	-	-	+	6
ũ	Dor, Lab	0	-	0	+	0	0	+	-	+	+	6
ẽ	Dor, Cor	0	-	0	+	0	0	-	+	-	+	6
ɘ̃	Dor	0	-	0	+	0	0	-	-	-	+	6
õ	Dor, Lab	0	-	0	+	0	0	-	-	+	+	6
ɛ̃	Dor, Cor	0	-	0	+	0	0	-	+	-	-	6
ɜ̃	Dor	0	-	0	+	0	0	-	-	-	-	6
ɔ̃	Dor, Lab	0	-	0	+	0	0	-	-	+	-	6
ã	Dor	0	-	0	+	0	0	+	-	-	-	6

I analyze the availability of spreading in terms of *the Rule of Most Specified*. Oral consonants cannot spread over nasals because they are equally specified (5 features). On the other hand, nasal vowels are more specified than any consonant other than /ɲ/.

I use two constraints: *C$\#_{\text{UTT}}$, which militates against utterance-final consonants, and *LINECROSS, which militates against crossed association lines.

(232) *C$\#_{\text{UTT}}$: 'Don't let utterances end in consonants'

Assign a violation for an utterance that ends in a C-slot.

(233) *LINECROSS: 'Don't allow association lines to cross'

Assign a violation for each pair of crossed association lines.

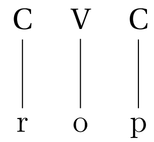
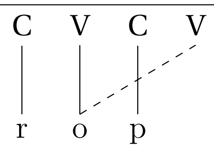
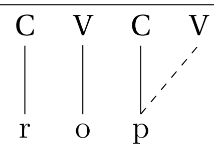
I also assume that *SPAWN[VOWEL] is dominated in Kĩsêdjê, allowing vowels to spread to multiple slots. Other varieties of *SPAWN are undominated, including *SPAWN[NAS], *SPAWN[LIQ], *SPAWN[OBS], and so on — only vowels may spread.

(234) *SPAWN[CONS]: Assign a violation for a [-SYLL] segment that is associated with more than one slot.

(235) *SPAWN[VOWEL]: Assign a violation for a [+SYLL] segment that is associated with more than one slot.

In a simple derivation of /rop/ → [rowo] 'jaguar' (225a.), the utterance-final C-slot is avoided by the vowel spawning another V-slot to its right. The preceding vowel spreads (candidate b.) instead of the consonant (candidate c.) because it is easier to lengthen vowel gestures than it is to lengthen consonants.

(236) Derivation of /rop/ → [rowo] 'jaguar'

/rop/	*C#$_{\text{UTT}}$	*SPAWN[CONS]	*LINECROSS	*SPAWN[VOWEL]
a.  [rop]	*!			
☞ b.  [rowo]			*	*
c.  [rowu]		*!		

When oral vowels are followed by a nasal consonant, however, vowel spreading is blocked due to the *Rule of Most Specified.* Nasals and oral vowels have the same number of features (5 features, see chart in (231) above), and their association lines cannot cross. The derivation is forced to do the next-best thing: insert features. Default vowel epenthesis is obtained by feature insertion (compare with Fongbe, Section 4.5.1), violating DEP[HI] (candidate b.) rather than spread from a consonant (candidate a.)

(237) Derivation of /mɛn/ → [mbɛni] 'honey'

/mɛn/	*SPAWN[CONS]	DEP[HI]	*LINECROSS	*SPAWN[VOWEL]
a. C V C V m ɛ n [mbɛnə]	*!			
☞ b. C V C V [+HI] m ɛ n [mbɛni]		*		

Let us now continue on to nasal transparency. Nasal vowels are more specified than oral ones. When a nasal vowel (6 features) is followed by a nasal consonant (5 features), spreading can still occur. This is shown in the derivation of /pãm/ → [pãmã] 'father' in (238) below:

(238) Derivation of /pãm/ → [pãmã] 'father'

/pãm/	*C#$_{UTT}$	*SPAWN[CONS]	*LINECROSS	*SPAWN[VOWEL]
a. C V C r o p [pãm]	*!			
☞ b. C V C V p ã m [pãmã]			*	*
c. C V C V p a m [pãmɨ]		*!		

When there is a palatal nasal /ɲ/, as in /pəɲ/ → [pəji] 'to arrive', spreading is expected to be uniformly blocked by *the Rule of Most Specified*. Palatals contain an additional feature, and that is enough to prevent vowels from spreading across palatal nasals in all contexts.

To summarize, while the Kĩsêdjê pattern is complex, the basic kinds of blocking effects are exactly what we expect under *the Rule of Most Specified*. As sounds become more specified, they are able to cross over more sounds. Parallel to this, as consonants become more specified, they are easier to cross over. The expected typology is thus where the overlap is possible in the most contrast-dense areas of a language's phonological inventory.

4.6 No Consonant Copying

A difference between spreading and correspondence analyses is if they predict consonant-vowel asymmetries. Kawahara (2007) identifies one such gap, which I call the *No Copying* generalization:

(239) NO COPYING: Consonant epenthesis never copies a non-adjacent consonant. (based off of Kawahara 2007)

In other words, there are no languages with consonant epenthesis that copies at a distance, as in (240a.). When suffixes are consonant-initial, no copying occurs (240b.), nor does any copying occur in bare forms (240c.).

(240) Hypothetical example of consonant copy epenthesis (unattested pattern)

a.	/pata-i/	[pata-ti]	/simo-i/	[simo-mi]	/okor-i/	[okor-i]
	/pata-i-a/	[pata-ti-ta]	/simo-i-a/	[simo-mi-ma]	/okor-i-a/	[okor-i-ra]
	/pata-en/	[pata-ten]	/simo-en/	[simo-men]	/okor-en/	[okor-en]
b.	/pata-to/	[pata-to]	/simo-to/	[simo-ti]	/okor-to/	[okor-to]
	/pata-ma/	[pata-ma]	/simo-ma/	[simo-ma]	/okor-ma/	[okor-ma]
c.	/pata/	[pata]	/simo/	[simo]	/okor/	[okor]

In a spreading account, this gap is straightforward. Vowels are known to spread over consonants, but the opposite is not widely true. This can be accomplished through the No Crossing constraint (Goldsmith, 1976), the Rule of Most Specified (Section 2.2.1), or through intuitions on gestural lengthening (Kawahara, 2007), the outcome is the same: consonants cannot spread over vowels without obscuring them.

Correspondence-based approaches cannot easily derive *No Copying*. There are two possible solutions. The first is to constrain consonant-consonant correspondence so that it must always be between adjacent segments. While a straightforward fix, it wouldn't address the deeper question, which is why long-distance correspondence between consonants is permissible in reduplication (base-reduplicant identity, McCarthy and Prince 1995), consonant assimilation (e.g. Hansson 2001; Rose and Walker 2004), and consonant dissimilation (e.g. Bennett 2013, 2015).

The second solution would be to deny that this is a meaningful gap, as in Stanton and Zukoff (2018: 36). The grammar should allow such patterns in principle, but we may not observe them for an entire host of reasons: a language like this might not exist at this point in time, or a language like this may not have been documented, or languages like this are hard to learn, and quickly are replaced by other patterns.

There is a deeper asymmetry here that my account derives. Consonants and vowels exhibit asymmetries in some phonological phenomena. I observe that both copy epenthesis and metathesis are widely attested with vowels, but not consonants. In my analysis, the reason why vowels can do this has to do with articulatory locality. Both of these phenomena involve extending vowel gestures past consonants, creating a contiguous vowel contour underneath consonantal gestures. Consonants cannot do this because consonants have no general contiguity requirement. In comparison, correspondence-based approaches do not derive this asymmetry without further stipulation, as are designed to easily derive non-local interactions (Rose and Walker, 2004). *No Copying* thus fits into the broader typology of asymmetries between consonants and vowels in the timing layer.

4.6.1 The No Copying Gap: a couple of putative counterexamples

In a typological survey on consonant epenthesis patterns (which I'll describe in Chapter 5), I identify a typological asymmetry where non-local consonant copying at the language-general level is unattested. The few patterns that resemble the hypothetical example in (240) all turn out to all be metamorph-level phenomena. In this section, I illustrate what these putative counterexamples look like, and argue that they cannot be analyzed as fully general patterns.

To illustrate, consider Afar, a Cushitic language spoken in Eritrea and Ethiopia (Bliese, 1981). Afar appears at first as if it could be a counterexample to *No Copying*. In some plural suffixes, Afar copies a preceding consonant (241):

(241) Afar (Cushitic) plural formation (Bliese 1981: 177)

	singular	plural	gloss
a.	[aˈmo]	[amoo-ˈma]	'heads'
b.	[giˈle]	[gilee-ˈla]	'knives'
c.	[anˈgu]	[anguu-ˈga]	'breasts'
d.	[diˈji]	[dijii-ˈja]	'charcoal'
e.	[abeeˈsa]	[abeesaa-ˈsi]	'vipers'
f.	[boosˈta]	[boostaa-ˈti]	'letters'

The copied consonant prevents vowel hiatus across a morpheme boundary, and it seems possible that Afar copying is driven purely by phonotactics. In consonant-final words (242), no consonant appears. Such nouns are affixed with either [-a] or [-wa] (which one is lexically specific).

(242) No copying in consonant-final words (Bliese, 1981)

	singular	plural	gloss
a.	[maco'lim]	[macolii'm-a]	'teachers'
b.	[ra'kub]	[rakuu'b-'a]	'camels'
c.	[ban'dug]	[banduu'g-a]	'rifles'
d.	[xu'tuk]	[xutuu'k-a]	'stars'
e.	[li'fic]	[lifii'c-a]	'nails, claws'
f.	[a'lib]	[alii'b-a]	'tendons'
g.	[a'bal]	[abal-'wa]	'game'
h.	[bu'lul]	[bulul-'wa]	'flour'
i.	[xaa'gid]	[xaagid-'wa]	'business'

Moreover, consonant copying is not the language-general strategy to avoid vowel hiatus. Elsewhere, vowels are deleted instead (243).

(243) Vowel deletion (not copying) is the productive strategy to avoid vowel hiatus (Bliese 1981: 177-178, 211, 263)

	UR	word	gloss
a.	/awka-i/	[aw'k-i]	'boy-NOM'
b.	/saaku-ih/	[saa'k-ih]	'day-GEN'
c.	/badeesa-ih/	[badee's-ih]	'snake-GEN'
d.	/ma-esser-inn-oto/	[m-esser-in'n-o]	'NEG-ask-PERF-1PL'
e.	/bagu-itte/	['bag-itte]	'abdomen-PL'
f.	/alsa-itte/	['als-itte]	'moon-PL'
g.	/cammi-itte/	['camm-itte]	'uncle-PL'
h.	/daagu-itte/	['dagg-itte]	'news-PL'
i.	/koori-itte/	['koor-itte]	'saddle-PL'
j.	/cudarejna-itte/	[cuda'rejn-itte]	'liar-PL'

Afar consonant copying appears to be phonotactically driven, but it is not general. The Afar plurals in (241) are therefore better analyzed in the metamorph layer as a kind of reduplication rather than language-general copy epenthesis, see Section 4.4.2 for a potential analysis. For now, I continue on to demonstrate how spreading predicts that no language should have Afar's consonant copying in as a general (timing layer) pattern.

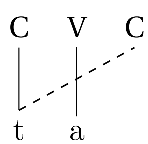
4.6.2 Lamination Theory: Deriving No Copying

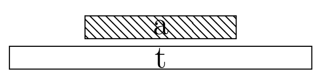
In Lamination Theory, *No Copying* is derived through assumptions on gestural contiguity. While it is possible for consonants to spread (244a.), consonants spreading over vowels is generally avoided by *the Rule of Most Specified*, where vowels are more specified than consonants (see Section 2.2.1). However, even if we dispense with this assumption, the derived output from consonant spreading will not be as desired: the consonant will contain the vowel, fully obscuring it, as in (244b.)

(244) Hypothetical language where consonants are more specified than vowels:

Spreading of consonants will still not obtain consonant copy-epenthesis

a. Representation b. Laminated output ☹ (not [tat]!)





/a/ contained in /t/

[tːt]

Surface correspondence relations are not possible in the timing layer. So, when spreading is ruled out, there should be no way to ensure identity at a distance in the timing layer. *No Copying* is thus obtained easily.

However, many models do allow free assignment of surface correspondence relationships, and I argue that these alternatives all face problems when deriving *No Copying*. Some examples of theories are Agreement-by-Correspondence type models (Rose and Walker, 2004), Host-Epenthetic correspondence (Kitto and de Lacy, 1999; Stanton and Zukoff, 2018), and also Zuraw

(2002)'s aggressive reduplication. Any model that allows phonological GEN to freely assign non-local surface correspondence relationships will fail to derive No Copying.

To illustrate, let's momentarily adopt Zuraw (2002)'s model of aggressive reduplication. Zuraw examines over- and underapplication in Tagalog pseudoreduplicated words, and argues that these involve the same type of coupling seen in reduplication. This coupling promotes identity between coupled substrings (CORR-KK), rather than between individual segments. The difference between reduplicated words and pseudoreduplicated words is that in one case, the need for coupling is morphological, whereas in the other it is phonological. Zuraw proposes REDUP, a phonological markedness constraint that promotes coupling:

(245) REDUP: A word must contain some substrings that are coupled. (Zuraw 2002: 405)

In the context of consonant epenthesis, REDUP is troublesome. For example, if we adopt a ranking where IDENT[F], REDUP ≫ DEP-IO ≫ CORR-KK, we should predict a language that has no aggressive reduplication except for in cases of epenthesis. Namely, it should be able to violate No Copying, as shown in (246b).

(246) No Copying predicted under Aggressive Reduplication – IDENT[F], REDUP ≫ DEP-IO ≫ CORR-KK

a. No aggressive reduplication in isolation

/batu/	*V-V	IDENT[F]	REDUP	DEP-IO	CORR-KK
a. batu			*!		
b. $[\text{ba}]_\alpha[\text{bu}]_\alpha$		*!			*
☞c. $[\text{ba}]_\alpha[\text{tu}]_\alpha$					**!
d. $\text{bat}[\text{tu}]_\alpha[\text{tu}]_\alpha$				**!	

b. Aggressive reduplication surfaces with epenthesis **(overgenerates No Copying!)**

/batu-o/	*V-V	IDENT[F]	REDUP	DEP-IO	CORR-KK
a. batu-o	*!		*!		
b. batu-wo			*!	*	
☞c. ba$[tu]_\alpha$-$[to]_\alpha$				*	*
d. ba$[tu]_\alpha$-$[wo]_\alpha$				*	**!

Similar problems arise with surface correspondence between segments, such as in Agreement By Correspondence theories (Rose and Walker, 2004; Walker, 2000). If GEN can create candidates that correspond at the surface, then there will always be a ranking that favors identity only for epenthetic segments.

So, how eliminate non-local consonant copying predictions? Kawahara (2007) suggests that that GEN must not be able to freely assign correspondence relations. Instead, Kawahara claims that all correspondence relations must be *morphologically licensed*, as in (247):

(247) Kawahara (2007): Restriction on correspondence

a. Every output correspondent of an underlying segment must be licensed by a morpheme M.

b. If a morpheme M licenses one output correspondent of an input segment S, M cannot license any other output correspondents of S.

But what does it mean for a morpheme to *license* correspondence? This idea remains underdeveloped. One interpretation is that licensing requires that a morphologically-indexed constraint to dominate a constraint against assigning surface correspondence relations. A problem with this is that if these rankings are all in the same derivation as ordinary phonotactics, then we would expect any kind of surface correspondence to be licit as long as some morpheme requires it.

In comparison, Lamination Theory does have an answer: long-distance surface correspondence relations can only be made by GEN in the metamorph layer. We therefore expect for phenomena that require long-distance correspondence to have specific morphological domains where it is applied. Timing GEN can never assign surface correspondence, and so the absence of these patterns in general patterns is expected.

4.6.3 Against compensatory reduplication

Putative counterexamples to No Copying have been claimed to exist in a phenomenon called *compensatory reduplication*. Compensatory reduplication refers to reduplicative copying that is phonotactically driven, not morphological (Yu, 2005). In this section, I briefly review the cases of compensatory reduplication that exist, and argue that they all are morphologically restricted in some way — they either satisfy infix templates or word minimality effects. I give one example here from Hausa. While I will not go through them in depth here, the other two cases from Yu (2005) (Spokane and Cantonese) have similar restrictions.

4.6.3.1 Hausa

In Hausa (Newman, 2000), class 5 plurals are typically realized as two discontinuous elements: a long [-aa] that infixes between the final two consonants of a CVCC stem and a suffix [-uu], as in (248i.). However, when a stem has a simplex coda, infixation does not occur. Instead, the plural suffix copies the final consonant of the stem, shown in (248ii.).

(248) Hausa (Class 5) plural (-aaCuu) infixes in CVCC words (i.) but reduplicates in CVC words (ii.) (Newman, 2000)

	root	singular	plural	gloss
i.	/gurb/	gurbíi	guráabuu	‘hollow place’
	/kurm/	kurḿii	kuráamuu	‘copse’
	/turk/	turkée	turáakuu	‘tethering post’
ii.	/gaɓ/	gaɓáa	gaɓáaɓ̱uu	‘joint, limb’
	/kaf/	kafáa	kafáaf̱uu	‘foot’
	/tsuw/	tsuwáa	tsuwáaw̱uu	‘testicle’

Depending on how one analyzes infixation, Hausa plurals could be construed as long-distance consonant copying. For example, if infixation is driven by a need to provide onsets in the plural suffix /-aa-uu/, then infixation and reduplication would both be ways to improve violations of ONSET. However, this analysis would imply that elsewhere in the grammar, consonant copying is also used to provide onsets. This is not the case: when vowel initial suffixes attach to a vowel-final stem, hiatus is normally resolved by deleting the first vowel (e.g. Class 10 plurals, Newman 2000: 453-456). Furthermore, in vowel-initial loans, they are typically adapted by inserting a glottal stop or [h], not by reduplicating a stem consonant (Newman 2000: 228).

4.7 Prosodic Identity Effects

Spreading accounts have been criticized in previous literature on the grounds that they do not naturally produce prosodic identity effects (Stanton and Zukoff, 2018). In this section, I demonstrate that certain kinds of prosodic identity can be captured with spreading.

4.7.1 Stanton & Zukoff (2018): Prosodic Identity through correspondence

Stanton and Zukoff (2018) argue that prosodic identity effects exist in a number of languages with copy epenthesis, including Selayarese, Barra Gaelic, and Ho-Chunk. Here I walk through the argument with Selayarese, and then proceed to show how similar effects can be derived in Lamination Theory (Section 4.7.2).

Stress is generally penultimate in Selayarese:

(249) Selayarese stress is usually penultimate (Mithun and Basri 1986: 220)

a. /sahala/ saˈhaːla ‘sea cucumber’

b. /sampulo/ samˈpuːlo ‘ten’

c. /bulaŋ/ ˈbuːlaŋ ‘month’

d. /kamuru/ kaˈmuːru ‘nose’

e. /kassi/ ˈkassi ‘sour’

Selayarese copy epenthesis occurs in loanwords that have an /s, l, r/ coda.[38] The preceding vowel copies over the consonant to create a vowel-final word, as in (251). The epenthetic copy vowels are underlined in (250a.) and (250b.).

(250) Stress is penultimate in words with medial copy vowels (Mithun and Basri, 1986)

a.	/kartu/	kaˈraːtu	'cards'
	/surga/	suˈruːga	'heaven'
b.	/solder/	soloˈdeːre	'solder'
	/karcis/	karaˈtiːsi	'ticket'

But, copy epenthesis can cause surface exceptions to penultimate stress assignment. When there is an epenthetic copy vowel in word-final position, the word receives antepenultimate stress. Compare above [ˈsaːhala] 'profit' (251a.) to [saˈhaːla] 'sea cucumber' (249a.). Word-final copy vowels are never stressed.

(251) Selayarese: Word-final copy epenthesis has antepenult stress (Mithun and Basri 1986: 237-238)

a.	/sahal/	ˈsaːhala	'profit'	cf. (249a.)
b.	/tulis/	ˈtuːlisi	'write'	
c.	/lamber/	ˈlambere	'long'	
d.	/botol/	ˈboːtolo	'bottle'	

Stanton and Zukoff (2018) analyze these facts in terms of prosodic identity. There is a correspondence relationship between the original "host" vowel and the epenthetic "copy". IDENTITY constraints between the host and epenthetic copy (HE-IDENT) prefer candidates where the epenthetic vowel matches in both quality and stress.

In (252), antepenultimate stress is a consequence of HE-IDENT[STRESS]. (The host vowel and its epenthetic correspondent must match in stress.) Penultimate stress is blocked because it would create a mismatch between those two correspondents (252b.).

[38] Mithun and Basri (1986) contest that this only occurs in loanwords, citing examples like *sambala* 'vegetable dish' as clearly indigenous words. While *sambala* is not a loan from a European language, it may be one from Indonesian *sambal*.

(252)

/botol/	NonFin	*Clash	HE-Ident[Str]	*LapseR
☞ a. bóːtolo				*
b. botóːlo			*!	
c. botóːló		*!		
d. botolóː	*!		*	

When epenthesis is word-medial, there is no way to avoid violating NonFin without also violating HE-Ident[Str] or *Clash. Stress therefore returns to the penult in words with just one medial copy vowel (e.g. [kaˈraːtu] 'cards') shown in (253), and words with two (e.g. [soloˈdeːre] 'solder') shown in (254).

(253)

/kartu/	NonFin	*Clash	HE-Ident[Str]	*LapseR
a. káraːtu			*	*!
☞ b. karáːtu			*	
c. káːráːtu		*!		*
d. karatúː	*!			*

(254)

/solder/	NonFin	*Clash	HE-Ident[Str]	*LapseR
a. sóːlodere			*	*!
b. solóːdere			*	*!
☞ c. solodéːre			*	
d. soloderéː	*!		*	

4.7.2 Lamination Theory: Deriving Prosodic Identity

Prosodic identity effects can also be derived in Lamination Theory by leveraging the representational layers. If we allow certain of prosodic constraints to be defined on different layers, then it is possible to derive patterns like Selayarese without issue. No surface correspondence is necessary.

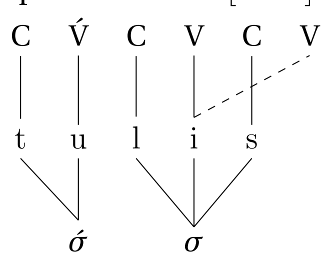
Let's examine the Selayarese case again. Recall, in Selayarese there were four main facts about the distribution of stress, reproduced in (255). First, words with no epenthesis have penultimate stress (255a.). When there is only an epenthetic copy vowel in the final syllable, stress ignores the copy vowel and occurs on the antepenult (255b.). Words with word-medial copy epenthesis always receive penultimate stress, regardless of if they have only one copy vowel (255c.) or two (255d.).

(255) Review of Selayarese prosodic facts (Broselow 2008, epenthetic vowels underlined)

a.	/sahala/	saˈhaːla	‘sea cucumber’	*No epenthesis, penult stress*
	/sampulo/	samˈpuːlo	‘ten’	
	/bulaŋ/	ˈbulaŋ	‘month’	
b.	/sahal/	ˈsaːhala	‘profit’	*Only final epenthesis, antepenult stress*
	/tulis/	ˈtuːlisi	‘write’	
	/lamber/	ˈlambere	‘long’	
c.	/kartu/	kaˈraːtu	‘cards’	*Medial epenthesis, penult stress*
	/surga/	suˈruga	‘heaven’	
d.	/solder/	soloˈdere	‘solder’	*Medial & final epenthesis, penult stress*
	/karcis/	karaˈtisi	‘ticket’	

In Lamination Theory, a form like [tuˈlisi] ‘write’ (255b.) would have the representation in (256):

(256) Representation of [tulisi] in Lamination Theory



tulisi

Note that in the CV diagram above, stress is marked both on the syllabic tier (in the metamorph layer) and on the V-slot. What is happening here is that stress is assigned on the bottom level, and percolates upwards.[39] Stress assignment is evaluated using information from both tiers.

Stress is generally penultimate in Selayarese, and so I introduce ALIGN(X,R) and NONFIN, which count the V-slots separating stress from the right edge.

(257) ALIGN(X,R): Assign one violation for each V-slot separating the stress from the right edge of the word.

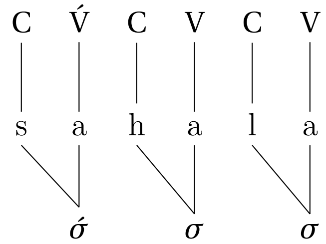
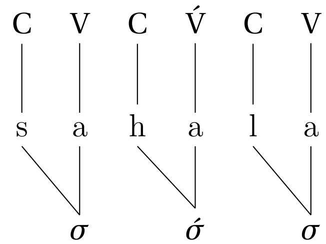
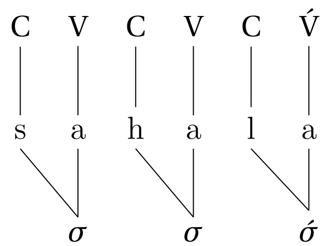
(258) NONFIN-V: Assign a violation if the final V-slot of the word bears stress.

When there is no epenthesis, we derive /sahala/ → [saˈhala] 'sea cucumber' by ranking ALIGN(X,R) ≫ NONFINV. Stress is assigned to one syllable and one V-slot as a consequence of CULMINATIVITY (Prince, 1983), which I modify here to require stress to occur once per level in each word.[40]

[39]I assume a prosodic well-formedness condition on stress percolation: a V-slot can only bear stress when it is associated to a feature that is associated with a stressed syllable. Intuitively, follow the lines from the V-slot down the tree, and a stressed V-slot must always be linked to a stressed syllable.

[40]We could also imagine things to be different, where every V-slot associated with a stressed syllable must bear stress. This could be the case in Barra Gaelic, which is why both initial vowel and peninitial copy receive stress (see Børgstrøm 1935:73,130, Bosch and De Jong 1997 1997).

(259) Derivation for /sahala/ → [saˈhala] 'sea cucumber'

/sahala/	NONFINV	ALIGN(X,R)
a.  ˈsahala		**!
☞ b.  saˈhala		*
c.  sahaˈla	*!	

For the cases with epenthesis, we'll need another constraint, which I call ONESTRONEV. ONESTRONEV assigns a violation whenever a stressed syllable is associated with more than one V-slot.[41]

(260) ONESTRONEV: Assign a violation if the stressed syllable is associated with more than one V-slot (a variation on HEAD-DEP, Alderete et al. 1999)

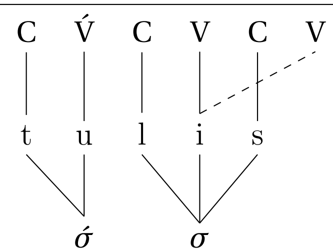
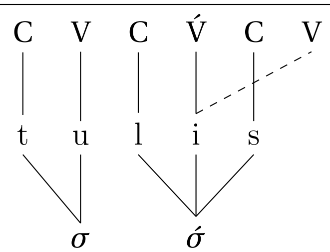
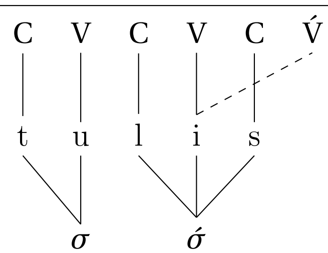
Analytically, ONESTRONEV serves a similar purpose to Alderete et al. (1999)'s HEAD-DEP constraint, which assigns violations for epenthetic vowels in a prominent prosodic foot. However,

[41]An alternative way of defining ONESTRONEV that does not use syllables: Assign a violation when a V-slot bears stress but does not have a one-to-one relationship with its associated feature bundle(s). I have no reason to prefer one over the other here, so I use the one that more transparently maintains my representational assumptions.

ONESTRONEV is slightly different. It is defined as a markedness constraint, and ONESTRONEV is also more general: it will assign violations for any kind of vowel multiple-association in stressed syllables, including from harmony and other forms of assimilation. Since stressed syllables are known to resist alternations often found in other positions (Beckman, 1998; Steriade, 1994), I consider this a desirable outcome.

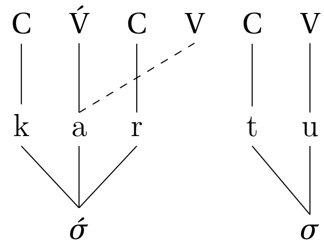
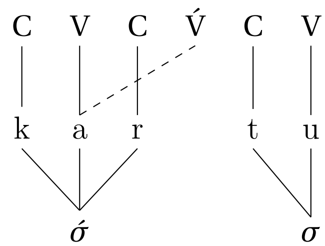
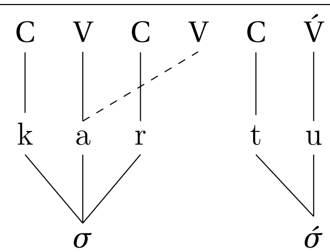
The derivation for /tulis/ → [tuˈlisi] 'write' in (261) proceeds straightfowardly. Stress would rather land on the antepenult (candidate a.) rather than have a multiply-associated vowel bear stress (candidates b. and c.).

(261) Derivation for /tulis/ → [ˈtulisi]

/tulis/	NONFINV	ONESTRONEV	ALIGN(X,R)
☞ a.  ˈtulisi			**
b.  tuˈlisi		*!	*
c.  tuliˈsi	*!		

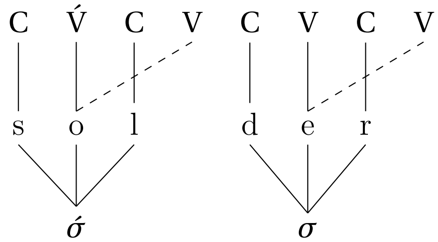
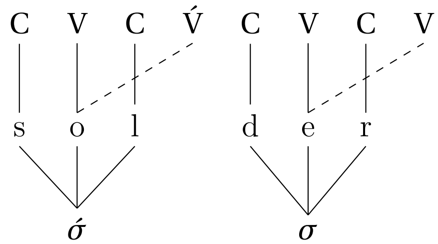
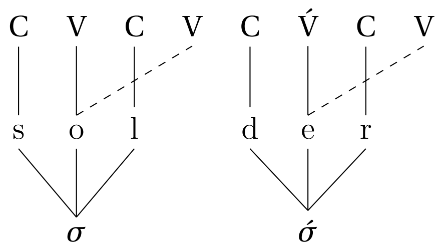
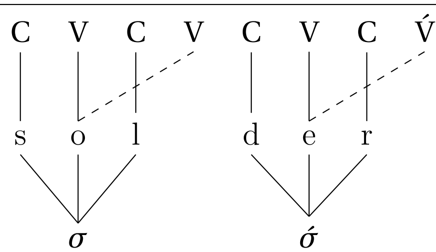
Words with medial copy-epenthesis, like [karátu] ‘cards’, there is no choice but to stress a multiply-associated vowel (262a. & b.), otherwise we would violate NONFINV (262c.).

(262) Derivation for /kartu/ → [kaˈratu] ‘cards’

/kartu/	NONFINV	ONESTRONEV	ALIGN(X,R)
a.  ˈkaratu		*	**!
☞ b.  kaˈratu		*	*
c.  karaˈtu	*!		

In quadrisyllabic words with two epenthetic copy-vowels, like /solder/ → [soloˈdere] in (263), ONESTRONEV will always be violated and so it plays no further role. Stress will therefore land on the penultimate V-slot, reverting back to the same scenario as roots with no epenthesis.

(263) Derivation for /solder/ → [soloˈdere] ‘solder’

/solder/	NONFINV	ONESTRONEV	ALIGN(X,R)
a.  ˈsolodere		*	***!
b.  soˈlodere		*	**!
☞ c.  soloˈdere		*	*
d.  solodeˈre	*!	*	

The Selayarese case raises several important questions for invisibility and stress assignment. The working hypothesis I develop here is that a certain amount of stress assignment is calculated quite early on by the metamorph layer. Stress at this point is assigned to syllables, not slots. This round of stress assignment may be weight sensitive (as in Sierra Miwok, Chapter 3), or it can be weight-insensitive, as in Selayarese, but it fixes stress onto an abstract syllable that cannot be changed by the timing layer.

By contrast, the role of timing layer stress constraints (like ALIGN(X,R)) is to determine how stress percolates up the layers onto slots. The core assumption here is that stress can only follow an contiguous upward path from syllable to slot — it is impossible for the timing layer to have one syllable stressed in the metamorph layer, and a totally unconnected slot stressed in the timing layer (e.g. *[karaˈtu] but with an abstractly stressed penultimate syllable). This contiguity assumption will generate much of the stress invisibility we need for cases like Andalusian Spanish (see Chapter 3), while still allowing enough flexibility for Selayarese.

To summarize, in this section I revisited the case of prosodic identity effects in Selayarese, where epenthetic vowels generally cannot bear stress. I demonstrate that a spreading account can derive these facts if we assume a layered representation as in Lamination Theory. Prosodic identity effects can be handled in either model, and therefore are not grounds to reject spreading.

4.8 Conclusion

In this chapter, I argued that copy epenthesis almost always has restrictions on (a) the vowels that participate, and (b) the consonants that may appear between the two copies. Partial reduplication, by contrast, does not show the same degree of segment sensitivity. I claimed that this is evidence in favor of analyzing these patterns in different terms: copy epenthesis as spreading, partial reduplication as long-distance correspondence.

I then turned to cases of long-distance consonant copying such as compensatory reduplication, where it appears that reduplication surfaces to only satisfy a phonotactic constraint. I demonstrated that compensatory reduplication actually has a highly restricted typology: copying only occurs to satisfy morphological requirements, such as infix templates. I therefore conclude that copying of vowel *segments* does not exist in general phonological grammar, it only occurs as a morphologically-driven effect.

Chapter 5

Consonant Epenthesis

5.1 Introduction

Lamination Theory contends that there are two kinds of phonology: one which modifies the fine timing and implementation of sounds as gestures, and another that manipulates segments. In this chapter, I focus on consonant epenthesis, and claim that Lamination Theory captures the typology better than salient alternatives.

In Lamination Theory, language-general and morphologically-conditioned occur in different representational layers, each with their own variety of phonological GEN. Language-general patterns occur the timing layer, using gestures, whereas morphologically-restricted patterns occur in the metamorph layer, using segments. The prediction is that in the typology of epenthetic consonant qualities, we should see two sets of patterns, one for each representational idiom.

Lamination Theory predicts that general patterns of consonant epenthesis should not be insertion of an abstract segment. After all, the timing layer cannot manipulate segments, only slots. I argue that general consonant epenthesis patterns are best analyzed in terms of lengthening existing gestures rather than inserting an entirely new segment. The kinds of segments that can "spawn" epenthetic consonants in this manner are precisely those that tend to spread in metathesis and copy epenthesis patterns — vowels, glides, and sonorants.

There is thus a deep asymmetry between morphologically-restricted patterns and language-general ones. General phonology has to make do with existing sounds, mutating them into phonotactically better shapes. Restricted phonology, on the other hand, can insert segments *ex nihilo*.

5.1.1 The problem

The typology of epenthetic consonants is controversial: even in the most basic empirical terms, it remains debated which epenthetic consonant qualities are attested, and which qualities constitute meaningful gaps. While the lack of consensus on the typology may be surprising, it is closely connected to the question of what constitutes a valid epenthesis pattern. Consonant-zero alternations are often ambiguous — they can be analyzed as either epenthesis or deletion (see recent discussion in Morley 2015). In the most restrictive theories, such as Staroverov (2014)'s splitting approach, epenthesis patterns are only selected from consonant-zero alternations that are fully general across a language. Consonant-zero alternations with limited generality (such as those that bear some element of morphological conditioning) are instead treated as deletion.

There is a question here that not been asked: does the typology of consonant-zero interactions differ significantly when it is morphologically restricted or language-general? If our goal is to create a constrained theory, this question must be answered. Whether or not the morphologically-restricted cases are "true" epenthesis or not can be debated later on, but the crucial fact is whether or not consonant-zero alternations form one cohesive set of patterns or if they must be divided further.

In this chapter, I claim that the typologies of general and morphologically-restricted consonant epenthesis patterns are distinct. On the basis of an original typological survey, I claim that epenthetic consonants are best understood in two main categories, as in (264).

(264) Main claim: Epenthetic consonants are divisible into two categories.

a. Language-general epenthetic consonants have a basic tendency to be assimilatory:

i. In intervocalic positions, they tend to be sonorants. **(LOUD AND PROUD)**

ii. Voiceless obstruents can only occur adjacent to consonants or word edges, never between two vowels **(MEEK AND DISCREET)**

iii. They are always invisible with respect to phonologically-conditioned allomorph selection (**INVISIBLE MAN**)

b. Morphologically-restricted epenthetic consonants may have a wider basic set of qualities, but there are different limits:

i. Quality is much freer. In intervocalic positions, these epenthetic consonants can be voiceless obstruents or fricatives. No observed tendency towards sonorants.

ii. The resulting segment must obey general well-formedness conditions in the language, and can only be selected from robustly contrastive sounds **(STRUCTURE PRESERVATION)**

No existing account derives all the generalizations in (264).

I put forward an analysis based on the intuition that epenthetic consonants have an inherent bias towards assimilation. All epenthetic consonants *spawn* from existing segments — they are the result of segments spreading onto an epenthetic C-slot. My spreading analysis builds on intuitive grounds as Staroverov (2014)'s Splitting Theory, which claimed that all epenthetic consonants split from existing vowels by violating INTEGRITY and IDENT. However, it differs in both its derived typology and mechanics. I claim that epenthetic consonants may also have part of their gestural target determined by markedness (violating DEP[F]), and thus that some features of epenthetic consnonants may not stem from any neighboring sound. The result is a theory where general epenthetic consonants emerge from neighboring sounds, but may be pressed into different shapes depending on markedness requirements.

5.1.2 Roadmap

The chapter is structured as follows. Section 5.2 discusses the typology and introduces four main generalizations: Loud and Proud, Meek and Discreet, Non-Structure Preservation, and Invisible

Man. Section 5.3 introduces the analysis. Sections 5.4-5.7 then discuss each generalization in turn. Section 5.8 discusses alternatives, and Section 5.9 concludes.

5.2 Typology

The typology of consonant epenthesis is by no means understudied. In just the last thirty years alone, some studies include Blevins (2008); Culhane (2018); de Lacy (2006); De Lacy and Kingston (2013); Inkelas (2014); Ito and Mester (2009); Lombardi (2002); McCarthy and Prince (1994); Morley (2015); Ortmann (1998); Rubach (2000); Staroverov (2014); Uffmann (2006, 2007); Vaux (2002); Żygis (2010).

These studies, while extensive, offer little consensus on what the typology of epenthetic consonants is. For instance, early work asserted that epenthetic consonants should be voiceless coronals (Broselow, 1984; McCarthy and Prince, 1994) on the grounds that these segments are cross-linguistically unmarked. Subsequent research expanded this typology to include glides and glottals (Alderete et al., 1999; Lombardi, 2002; Steriade, 2001), liquids (Uffmann, 2007), and nasals (de Lacy, 2006), with the main generalization being that epenthetic consonants are either coronals or sonorants. However, others have since contended that the typology is far more restricted, allowing only glottals, glides and voiced dorsals like [g] and [ɣ] (Staroverov, 2014). Others yet contend there are no hard synchronic restrictions on the qualities of epenthetic consonants, only diachronic ones that bias certain segments over others (the diachronic approach, Blevins 2008; Vaux 2002.

The reported set of epenthetic consonants (from the sources above) is shown in (265), though most theories only derive a subset of these qualities. (See Appendix A.2 for full details on the literature meta-review.)

(265) Reported epenthetic consonant qualities from the literature (146 patterns, 34 families, 4

isolates)

	Labial	(Post-)Alveolar	Palatal	Velar	Uvular	Glottal
Plosive	p b	t d		k g		ʔ
Nasal	m	n		ŋ		
Liquid		r ɹ l				
Affricate		dʒ				
Fricative	v	s ʃ ʒ		x ɣ	ʁ	h
Approximant	w ʋ		j			

The question remains: is the typology of epenthetic consonants restricted in any way? Is (265) an accurate representation of the typology of epenthetic consonants, or are there further generalizations?

In this section, I present an in-depth typological study on consonant epenthesis, drawing both from existing surveys and a novel survey of 2600 digitized grammars (approximately 1500 languages). I contend that the typology in (265) is too restrictive in some dimensions, and too unrestricted in others.

In the first case, I find several languages bear epenthetic qualities that were unattested in previous typological surveys. One example comes from the Molo dialect of Meto, which inserts [b, l, ɟ] to avoid hiatus across root-suffix boundaries. While [b, l] are attested in previous studies, [ɟ] is novel. Cases such as Molo thus appear an ill omen for producing a restrictive theory of consonant epenthesis, since it suggests that even the broad typology in (265) contains false gaps.

A second major generalization is that the typology of epenthetic consonant qualities is dependent on the generality of the pattern. When epenthesis is fully general across a language, epenthetic consonants have a strong tendency to be assimilatory. Molo is an example of this, where the preceding vowel conditions the place of the epenthetic consonant. However, when consonant epenthesis is morphologically restricted, the assimilatory bias disappears. The attested qualities in morphologically-restricted epenthesis patterns often appear to be phonotactically arbitrary. This difference is predicted in Staroverov (2014)'s Splitting Theory, where morphologically-restricted patterns are uniformly treated as deletion. Other analyses, however, such as TETU-based markedness accounts (Lombardi, 2002; McCarthy and Prince, 1994), do not necessarily predict these typologies should pull apart.

I begin by presenting my original typological survey (Section 5.2.1), and then demonstrate that language-general epenthetic consonants are frequently assimilatory (Section 5.2.1.3). Section 5.2.2 then presents four main generalizations from the survey.

5.2.1 Typological survey

The primary source survey consisted of a broad search of around 2600 digitized grammars for consonant epenthesis patterns (approximately 1500 languages, some languages had more than one grammar in the sample). I also included data on Meto (Austronesian) from my own fieldwork. This section is structured as follows: Section 5.2.1.1 discusses the procedure for the survey, Section 5.2.1.2 presents the results on quality, and Section 5.2.1.3 shows the assimilatory tendencies of the two kinds of epenthetic consonants.

5.2.1.1 Procedure and Languages Surveyed

The procedure for generating the grammar sample consisted of searching for the terms *consonant epenthesis*, *epenthetic consonant*, *consonant insertion*, *consonant gemination*, along with related stems. From there, the grammars containing those terms were examined more closely to determine if a consonant epenthesis pattern was present.[42]

Each consonant epenthesis pattern was then marked for its morphological restrictions, non-local assimilation, epenthetic segmental quality, structure preservation, and any interactions with other phonology. This yielded 60 consonant epenthesis patterns, 32/60 of which were language-general. Patterns with asterisks only apply to loanwords — these cases can present

[42]This procedure is expected to slightly under-count the number of epenthesis patterns in these grammars — some grammars used different terminology, such as *glide formation*, */t/ insertion*, and so on, which would not be selected by the search terms above. (Searching for just "insertion" was attempted, but this returned almost the entire 2600 grammar sample, because "insertion" is frequently used when discussing morphology like case.) While it would be possible to include such terms, the risk is that this would introduce additional bias into the census, which was also meant to assess the frequency of different consonant qualities.

a tricky issue for determining whether or not they are morphologically restricted. On one hand, loanwords often bear exceptional sequences of sound not found in native words, and so loanwords may be the only place in the language where the context for epenthesis arises. On the other hand, speakers may recognize this, and partition the lexicon so that loanwords form their own morphological class, which could allow them to use metamorph-type strategies even though the pattern is exceptionless. To avoid this murky area, I consider loanword patterns separately wherever possible.

Family	Language	Segment	Source
Algic	Ojibwe	j	Rhodes 1976: 13-14
Austronesian	Ida'an	j, w	Goudswaard 2005: 31-32
	Ilocano	t, d, ʔ	Rubino 1997: 28, 109
	Meto (Amarasi)	g	Edwards 2016; Mooney 2023
	Meto (Molo)	b, l, ɟ	Mooney 2023
	Mato	k, g	Stober 2013: 21-22
	Neverver	b	Barbour 2012: 63
Benue-Congo	Kisi	j, w	Childs 1988: 65-66
Cangin	Noon	n	Soukka 1999: 52
Cariban	Carib	j	Courtz 2008: 40-41
Caucasian	Khwarshi	j	Khalilova 2009: 37
Chadic	Goemai	g, ɣ	Hellwig 2011: 36
	Wandala	h	Frajzyngier 2012: 61
Creole	Nigerian Pidgin	j, w, r	Faraclas 2005: 258
	*Sri Lankan Malay	ŋ	Nordhoff 2009: 136
Cushitic	Somali	j, ʔ	Saeed 1999: 26
Indo-European	Old English	p, b, t, d	Hogg 2011: 292
(isolate)	Huave	j	Kim 2008: 75-77
	Xincan	ʔ	Rogers 2010: 125
Khoisan	Sandawe	g	Steeman 2012: 96
Macro-Je	Apinajé	m	de Oliveira 2005: 76-77
Mayan	*Mocho'	x	Palosaari 2011: 109-110
Muskogean	Choctaw	ʔ	Broadwell 2006: 27-28
Nambikwaran	Mamaindê	p, t	Eberhard 2009: 282
Omotic	Bambassi (Mao)	ʔ	Ahland 2012: 58
Papuan	Doromu-Koki	j	Bradshaw 2012: 39
	Motuna	j, w	Onishi et al. 1994: 21
	Teiwa	ʔ	Klamer 2010: 49
	Urim	p, t, k	Hemmilä and Luoma 1987: 12
Penutian	Mutsun	ʔ	Okrand 1977: 25-27
Quechuan	*Quechua (Huallaga)	g	Weber 1989: 476
Sino-Tibetan	Tibetan (Dongwang)	m, n, ŋ, x, h	Bartee 2007: 41
Totonac-Tepehua	Totonac	j, ʔ	McFarland 2009: 37-39
Tucanoan	Wanano	ʔ	Stenzel 2004: 60-65
Tupian	*Tapiete	ʔ	González 2005: 272
Turkic	Turkish	j	Hieber 2007: 18
Languages sampled: 36			
Language families: 24 (and 2 isolates)			

Table 5.1: Primary source survey: Languages with **language-general** consonant epenthesis.

Family	Language	Segment	Source
Algic	Arapaho	t, n	Moss and Cowell 2008: 61, 277-278
	Blackfoot	t	Taylor 1969: 146-147
	Ojibwe	d	Rhodes 1976: 13-14
Australian	Gooniyandi	b, w, dʒ, j	McGregor 1990: 205
Austronesian	Lote	x	Pearson and van den Berg 2008: 22-23
	Maori	m, t, r, k, ŋ, h	Harlow 2007: 118
	Mavea	v	Guérin 2006: 121
	Siar	r, l	Frowein 2011: 320-321
Bantu	Kpwe	h	Henson 2007: 193-194
Cariban	Carib	l, n	Atindogbe 2013: 17, 99-100
Caucasian	Ingush	v, n	Nichols 2011: 128
Cushitic	Afar	copy	Bliese 1981: 177
Eskimo-Aleut	Yupik (C. Alaskan)	ɣ	Miyaoka 2012: 223-224
Hibito-Cholon	Cholon	n	Alexander-Bakkerus 2005: 123
Indo-European	Polish	t, d, k	Bielec 2004: 45
(isolate)	Basque	r	Laka Mugarza 1996: 67-68
Macro-Je	Bororo	t, d, n, k, g	Crowell 1979: 14-15, 208-209
Mayan	Chol	j, w	Vázquez Álvarez 2011: 51-54
Nambikwaran	Sabanê	l, t	De Araujo 2004: 69
Nilo-Saharan	Lango	r	Noonan 1992: 22
Yuki-Wappo	Wappo	ʔ, t	Thompson et al. 2006: 123-129
Omotic	Dime	j	Seyoum 2008: 39
Sino-Tibetan	Rabha	ŋ	Joseph 2007: 124
Tungusic	Udihe	w	Nikolaeva and Tolskaya 2011: 79
Turkic	Turkish	n, s	Hieber 2007: 28
Uto-Aztecan	Ute	j	Givón 2011: 99
Volta-Niger	Oko	n	Atoyebi 2009: 65
Wakashan	Nuu-chah-nutlh	q	Davidson 2002: 173-174
Yeniseian	Ket	ɣ	Georg 2007: 87
Languages sampled: 29			
Language families: 23 (and 1 isolate)			
Total languages in sample: 60			
Language families represented: 36			

Table 5.2: Primary source survey: Languages with **morphologically-restricted** consonant epenthesis.

5.2.1.2 Results: Consonant Quality

The consonant qualities found in the grammar survey are reported in (266). Similar to the literature meta-review, glides, liquids, and nasals were all attested (especially in intervocalic contexts), and stops were found when epenthesis occurred next to other consonants. Fricatives were rarer, and when they were found, they tended to be in morphologically-restricted patterns. Qualities that are only attested in morphologically-restricted patterns are circled in (266).

(266) Primary Source Survey: attested epenthetic qualities (only morph.-restricted are circled)

	Labial	(Post-)Alveolar	Palatal	Velar	Uvular	Glottal
Plosive	p b	t d	ɟ	k g	ⓠ	ʔ
Nasal	m	n		ŋ		
Liquid		r ɹ l				
Affricate		(dʒ)				
Fricative	ⓥ	ⓢ		x ɣ		h
Approximant	w		j			

In comparison to the typology from the literature meta-review in (265), there are several gaps in this typology. For one, there are no language-general cases of /s/ or /v/ epenthesis. Fricatives, when they occur in general patterns, must be dorsal or laryngeal.

Similarly, stops were found at essentially all places of articulation, and there was no observed tendency towards coronals. Later on, I demonstrate that consonant PLACE is generally inherited from neighboring vowels. In most languages, this means that epenthetic consonants will be DORSAL, but other qualities are well, such as labials (following round vowels) or coronals (following certain front vowels).

Between these two kinds of patterns, consonant quality is distributed differently. Language-general epenthesis is mostly comprised of glides and glottals, with oral stops the next most common. In comparison, morphologically-restricted epenthesis is more evenly distributed between liquids, nasals, stops, and fricatives. This is shown in Figure 5.1.

In historical terms, this distribution is highly intuitive. If language-general epenthesis arises

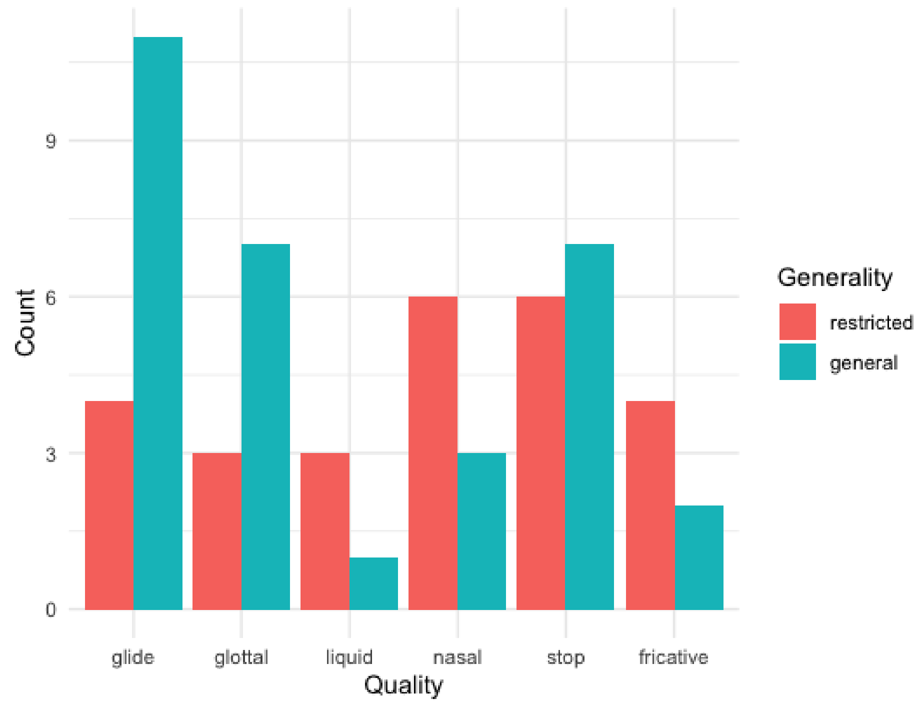


Figure 5.1: Qualities of epenthetic consonants in general and restricted patterns.

from coarticulatory pressures, then we would expect glides and glottals to be common, since these are both perceptually and articulatorily minimal (Blevins, 2008). Morphologically-restricted patterns, by contrast, are expected to arise from reanalysis of existing morphemes (e.g. a -CV suffix to a -V suffix with epenthesis), and so any consonant quality that is possible in these morphemes should be possible as an epenthetic consonant.

In Section 5.6, I'll demonstrate that the typology of language-general epenthesis bears even stronger restrictions when we factor in the conditioning environment. Glides, glottals, and liquids form the overwhelming majority of intervocalic language-general epenthetic consonants. Voiceless stops, on the other hand, are only possible when they are adjacent to a consonant or word edge. This marks yet another difference between language-general and morphologically-restricted patterns, since morphologically-restricted patterns have no such restrictions on where it is possible to epenthesize oral stops.

5.2.1.3 Results: Assimilation

The language-general patterns also had a higher rate of partial or full assimilation, as in (267). In the language-general patterns, 8/36 transparently shared place with a local consonant or vowel, in comparison to only 1/29 of the morphologically-restricted epenthesis patterns. Additionally, if we adopt Staroverov (2014)'s assumption that all vowels bear a [DORSAL] feature, this allows us to treat all epenthetic dorsals as sharing place with an adjacent vowel. Under this assumption, 15/36 language-general patterns share PLACE, whereas only 5/29 in morphologically-restricted patterns do.

A small number of language-general epenthetic consonants insert coronals, regardless of the surrounding sounds. These two cases are Nigerian Pidgin, which inserts /r/ intervoalically (and is in free variation with glides), and Noon (Cangin), which inserts /n/. It is worth noting that both of these are sonorants that are epenthesized intervocalically — exactly what we expect under *Loud and proud*. While these cases are less transparently assimilatory than the PLACE examples, they occupy a middle ground: as sonorants, they are more vowel-like than obstruents, and so could be construed as partially assimilating with the surrounding vowels.

There were patterns where epenthetic obstruents did not clearly share PLACE or manner, but all of these were morphologically-restricted (10/29 patterns). These included cases like Blackfoot /t/ (Taylor 1969: 146-147), Polish /t, d, k/ (Bielec 2004: 45), and Maori /t, d, k, r, m, ŋ, h/ (Harlow 2007: 118).

The remaining cases (for both language-general and restricted types) were all glides and glottals. These, too, can be considered assimilatory with vowels. For glides, this is fairly obvious — they form a natural class with vowels in being [-CONS]. Glottals are a more difficult case, but the reasoning here is that if there is a glottal constriction, it is not possible to tell if it assimilates with oral gestures without articulatory methods or comparing formant trajectories. In lieu of data of this type, I assume that epenthetic glottals are featurally identical with glides other than their laryngeal constriction.

(267) Most language-general consonants are assimilatory

	Lg.-general	Morph.-restricted
Share PLACE with local C	7	1
Share PLACE with local V (dorsal only)	7	4
Share PLACE with local V (all places)	1	0
Sonorants that do not transparently share PLACE	2	8
Obstruents that do not share PLACE or manner	0	10
Glides	11	4
Glottals	8	2
Total	36	29

I interpret these data in the strongest possible terms: language-general patterns are always assimilatory. This claim relies on treating glottals and glides in similar terms. The oral place and manner of the glide or glottal closely matches surrounding vowels, and they only differ in the degree of laryngeal constriction. Later on, the claim that all epenthetic consonants are assimilatory will be critical for creating a constrained theory of consonant epenthesis.

5.2.2 Four Generalizations

I formulate four main generalizations on epenthetic consonants from the typological survey. They are shown in (268)-(271) below.

(268) **STRUCTURE PRESERVATION:**

a. Language-general epenthetic consonants may produce sounds that are not robustly contrastive in the language, and are only attested as the result of epenthesis.

b. Morphologically-restricted epenthetic consonants must always be structure-preserving, meaning that they must select from within the set of contrastive sounds of a language. (Concretely: whatever epenthetic consonant is used, it is always a consonant also found in roots.)

(269) **LOUD AND PROUD:**

a. Language-general epenthetic consonants tend to be sonorants or glottals in intervocalic positions.

b. Morphologically restricted epenthesis has no tendency towards sonorants in intervocalic positions.

(270) **MEEK AND DISCREET:**

a. Language-general epenthetic consonants can never be voiceless obstruents in intervocalic positions. Voiceless obstruents, when they arise, must occur next to another consonant or a word edge.

b. Morphologically restricted epenthesis has no restrictions on voiceless obstruents.

(271) **INVISIBLE MAN:**

a. Language-general epenthesis patterns are always phonologically invisible with respect to allomorph selection, weight-driven stress assignment, reduplication, and word minimality

b. Morphologically-restricted epenthesis patterns may be phonologically visible

The first generalization, Structure Preservation, is the observation that language-general consonant epenthesis can introduce segments whose distribution is not robustly contrastive. Morphologically-restricted epenthesis, in comparison, can only use segments that are otherwise well-attested. The name for this generalization comes from structure preservation in Lexical Phonology: lexical rules were posited to be structure-preserving, meaning that they can only create outputs that could also be possible inputs to that same stratum. This differed from postlexical rules, which could create sounds that were strictly allophonic.

An example of a non-Structure-Preserving pattern is /g/ epenthesis in Amarasi (data from fieldwork, see Section 5.4.1). When a vowel-initial suffix attaches to a vowel-final stem, hiatus is avoided by epenthesizing /g/.

(272) **Non-Structure-Preservation:** /g/ epenthesis in Amarasi

	UR	suffixed form	gloss	bare form
a.	/meo-e/	meog-e	'the cat'	meo
b.	/ʔao-es/	ʔaog-es	'a body'	ʔao
c.	/noe-es/	noeg-es	'a river'	noe
d.	/tasi-e/	taisg-e	'the sea'	tasi

Amarasi does not have /g/ in roots, and loanwords with initial /g/ are uniformly adapted as /k/. Epenthesis in Amarasi is thus non-Structure Preserving, since it introduces a surface segment that is not found elsewhere in the language. In constraint-based frameworks like OT, this is surprising because the outputs in (272) invert the expected distribution of contrastive segments: contrasts are expected to be maximized in roots and initial syllables (Beckman, 1998; Gouskova, 2021), and yet we only see /g/ in derived contexts at the right edges of words.

The second generalization I dub the *Loud and Proud* generalization, which states that intervocalic epenthetic consonants tend to be sonorants or glottals in language-general patterns. The intuition behind this generalization is that epenthetic segments often co-opt existing sounds, solidifying them into consonants that can mark morpheme boundaries, resolve sonority clashes, or prevent vowel hiatus. An example of Loud and Proud is from Noon (Cangin, Soukka 1999), which inserts /n/ to avoid hiatus between stem and suffix:

(273) **Loud and Proud**: /n/ epenthesis in Noon (Soukka, 1999)

	UR	suffixed form	gloss	bare form
a.	/oːmaː-iː/	oːmaː-niː	'the child'	oːmaː
b.	/mati-o/	mati-no	'Mati!'	mati
c.	/músú-aː/	músú-naː	'water-SUBJ'	músú

Other influential approaches to consonant epenthesis, especially those in early Optimality Theory, do not predict *Loud and Proud*. Instead, they make the *opposite* prediction, where voiceless obstruents and glottals are expected to be the most common (e.g. Lombardi 2002;

McCarthy and Prince 1994), based on the argument that these segments are the least marked overall.

The main difference between theories that predict *Loud and Proud* and those that don't is how context sensitivity is built into the model. When epenthetic quality is determined by segmental or featural markedness constraints (e.g. *STRUC), then sonorants are generally not predicted. By contrast, when quality is determined by trigram constraints (Uffmann, 2007), syllabic position (de Lacy, 2006), contextual perceptibility (Steriade 2001/2009) or faith with surrounding sounds (Staroverov, 2016, 2014), then sonorants are expected. My analysis joins this latter category. Epenthetic consonants are mutations of local gestures, and so epenthetic consonants between two vowels have no choice but to draw from vowels.

This leads me to the third generalization, *Meek and discreet*, which is the mirror image of *Loud and Proud*. Voiceless epenthetic consonants only appear (i) in non-intervocalic positions, or (ii) in morphologically-restricted patterns. An example of *Meek and discreet* comes from Blackfoot, which epenthesizes /t/ between person prefixes and the verb stem, as in (274). When these same person prefixes attach to inalienable nouns, no /t/ is inserted (275). I therefore treat the Blackfoot case is morphologically restricted.

(274) A violation of **Meek and discreet** in a morphologically-restricted case: /t/ epenthesis in Blackfoot (Taylor 1969: 146-147)

	UR	prefixed form	gloss	
a.	/ni-ɪʔnitaːwa/	ni-t̲siʔnitaʔwa	'I killed him'	ɪʔnita 'murder one'
b.	/o-ɪpɪɪsʃi/	ot̲s̲-ɪ́pissi	'when, that he entered'	
c.	/ki-ɪniʃki/	kit̲s̲-ɪ́nʔixki	'thou didst sing'	

(275) Blackfoot: Inalienable nouns do not allow /t/ epenthesis (Taylor 1969: 147)

	UR	prefixed form	gloss
a.	/ni-ooʔtokáán/	n-ooʔtokáán	'my head'
b.	/ki-ooxkówaaʔa/	k-ooxkówaaʔa	'your son'
c.	/o-otokisi/	o-tokís	'his hide'

By contrast, language-general epenthesis can only produce voiceless obstruents in three restricted environments. They may occur next to another stop (e.g. Mamaindê, /eu-tʃihtaʔ/ → [ˈeup̠-tʃihraʔ] 'in order to see', Section 5.5.1.5), they may occur between two consonants (e.g. Ilocano, /bisrad-en/ → [bistrad-en] 'spread open', Rubino 1997: 28), or at word edges (e.g. Mocho', /mesa/ → [mešax] 'table (loanword)', Palosaari 2011: 109-110). When voiceless obstruents occur in intervocalic contexts, I demonstrate that these cases are always morphologically restricted (e.g. Axininca Campa, Section 5.3.3.2).

The last generalization, Invisible Man, concerns the visibility of general epenthetic consonants. Phonologically-conditioned allomorphy is freqently sensitive to whether a stem is vowel- or consonant-final. However, general epenthetic consonants are never counted for allomorphy. One example here comes from Washo (Staroverov, 2016), which epenthesizes a glottal stop in word-initial contexts. The word-initial glottal stop does not condition the allomorph expected for consonant-initial words, shown in (276) below, instead taking the [m-] allomorph.

(276) **Invisible Man:** /ʔ/ epenthesis is invisible to allomorph selection in Washo (Staroverov 2016: 482)

a.	/aŋal/	→ ʔ̠aŋal	'house'	c.	m-aŋal	'your house'
	/emlu/	→ ʔ̠emlu	'food'		m-emlu	'your food'
b.	/ʃuː/	→ ʃuː	'chest'	d.	ʔum-ʃuː	'your chest'
	/ʔaːt'u/	→ ʔaːt'u	'older brother'		ʔum-ʔaːt'u	'your older brother'

No language-general epenthesis was phonologically visible to allomorphy or stress assignment. The behavior of morphologically-restricted epenthesis remains open, however. While these cases were examined, no clear cases of visibility or invisibility were found.

5.3 Analysis

I claim that consonant epenthesis is split into two separate typologies: language-general and morphologically-restricted patterns. Language-general consonant epenthesis is always at least partially assimilatory. Morphologically-restricted epenthesis, on the other hand, appears to be more variable in quality, and does not have the same tendency towards local assimilation. I summarize some of the key differences in (277) below:

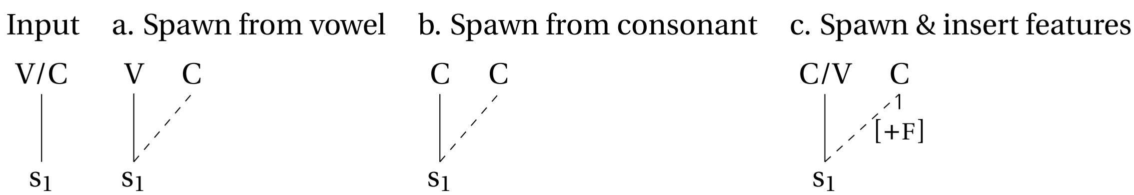
(277) Key differences between language-general and morphologically-restricted consonant epenthesis

	Language-general	Morphologically-restricted
Quality assimilatory to nearby segments?	✓	–
Sonorant bias?	✓	✗
Voiceless obstruents intervocalically?	✗	✓
Is the epenthetic seg. robustly constrative?	–	✓
Epenthesis visible to allomorphy?	✗	✓

To capture these generalizations, I cast my analysis in Lamination Theory. Lamination Theory contends that language-general and morphologically-conditioned occur in different representational layers, each with their own variety of phonological GEN. Language-general patterns occur the timing layer, using gestures, whereas morphologically-restricted patterns occur in the metamorph layer, using segments. The expectation is that in the typology of epenthetic consonant qualities, we should see two sets of patterns, one for each representational idiom.

In the timing layer, consonant epenthesis is driven by general considerations of markedness: the need for syllables to have onsets, for prosodic boundaries to align with syllable edges, or to avoid otherwise hard-to-coordinate sequences of sound such as vowel hiatus. Epenthetic consonants are created by a segment spreading to a new slot, either from vowels (278a.) or consonants (278b.). Features may be inserted at the epenthetic slot as required by other kinds of markedness (278c.). I call this *spawning*, since the resulting outputs violate *SPAWN in (279), the constraint against segments associating with multiple slots.

(278) Three ways of forming epenthetic consonants with spawning



(279) *SPAWN: 'Segments should associate with just one slot'

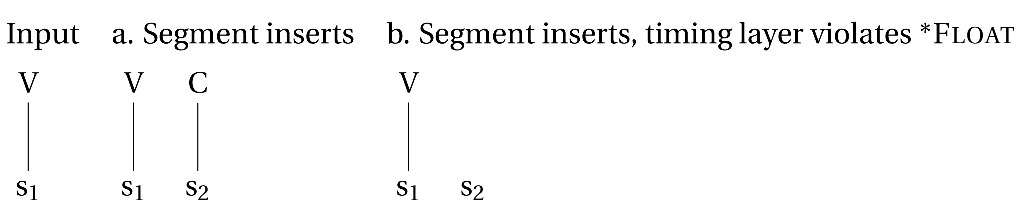
For a segment x that is associated with a slot C_i/V_i, assign a violation for each slot C_j/V_j that is also associated with x.

In this way, epenthetic consonants are essentially a mutated form of sounds already present. A gesture lengthens, and then is pressed into a shape that optimally satisfies surface markedness.

In comparison, morphologically-restricted consonant epenthesis is driven by markedness requirements indexed to particular morphemes. I assume that the markedness constraints in the metamorph layer are quite similar to those in the timing layer — constraints like ONSET (Prince & Smolensky 1993: 17), CRISPEDGE (Itô and Mester, 1994, 1999), and FINAL-C (McCarthy, 2003b) can all drive consonant epenthesis, they are simply defined for segments rather than slots, and must bear a morphological index shared with a subset of the lexicon.

Metamorph GEN, however, differs in that it can insert entirely new segments. Whether or not these segments are associated with a C-slot is entirely up to the timing layer; the metamorph layer inserts them blindly, as that is all the information it has access to. In (280), I show two possible outcomes for epenthesis in the metamorph layer: straightforward insertion of a "full" consonant (280a.), or insertion of a consonant that does not meet its articulatory target (280b.).

(280) The metamorph layer inserts a new consonant segment



Exactly how quality is determined in the metamorph layer appears more open — for the time being, I assume a markedness based approach, but non-optimizing analyses such as readjustment rules remain a possibility.

These two layers thus differ in what drives epenthesis and what resolves it. In the timing layer, consonant epenthesis is driven by general phonotactic principles, and existing sounds are repurposed to make things more pronounceable. In the metamorph layer, consonant epenthesis is driven by well-formedness conditions on segments within specific classes of morphemes, and is carried out via phonotactically arbitrary insertion mechanisms. The difference is that in the timing layer, morphemes only matter insofar as they introduce boundaries, but in the metamorph layer, abstract morpheme structure is the primary thing being improved.

5.3.1 Formal details

To derive the typology of language-general patterns, I assume two restrictions on GEN in the timing layer:

(281) Assumed restrictions on timing GEN:

a. The only way to insert slots is to spread. There is no insertion of empty slots.

b. The only way to modify segment targets is to layer features on top of them, violating DEP[F]. No feature rewriting is possible (No IDENT[F]).

The first assumption is motivated by the fact that language-general epenthetic consonants are always assimilatory (see chart in (267) in Section 5.2.1.3). On an intuitive level, we need to require that every epenthetic consonant has some relation to an existing sound. In my analysis, I do this by requiring that insertion of a C-slot is accompanied by spreading from a local sound. This often induces violations of *SPAWN. When the spreading segment is a vowel, consonant epenthesis also violates *VTOC.

(282) *SPAWN: ‘Segments are associated with just one slot’

For a segment x associated with a slot C_i/V_i, assign a violation for each additional slot C_j/V_j that is also associated with x.

(283) *VTOC: Assign a violation for a vowel segment associated with a C-slot.

Previous accounts of consonant epenthesis have made similar assertions. For example, in Splitting Theory, Staroverov (2014) restricts GEN to only allow epenthetic consonants when they are co-indexed with a neighboring vowel. A similar idea also arises in Kitto and de Lacy (1999), who capture vowel copy-epenthesis as a kind of correspondence, where the base vowel and epenthetic vowel must correspond.

While intuitively similar, my theory differs in two ways. First, I treat the identity relation as spreading, rather than correspondence. This has implications for the availability of consonant copy epenthesis discussed in Section 4.6. Under my analysis, the epenthetic consonant does not need to be segmentally adjacent to its conditioning host (a requirement in Staroverov's analysis), it only needs to be gesturally contiguous. Second, both Staroverov (2014) and Kitto and de Lacy (1999) assume that correspondence relations can only be made between an epenthetic segment and a *vowel*. My analysis poses no such restriction — both consonants and vowels may spread to form epenthetic consonants.

In addition to cases that are transparently assimilatory, there are also consonant epenthesis patterns where assimilation is partial — either the manner or PLACE of the epenthetic consonant do not clearly match that of surrounding sounds. Examples of this include /j/ insertion in Washo (Staroverov, 2016) and /n/ insertion in Noon (Section 5.5.1.3). I derive these patterns with a feature insertion mechanism, DEP[F] (Archangeli, 2000; Krämer, 1998, a.o.), which allows epenthetic segments to gain features not present in the input (such as nasality, in the case of Noon).

The reasoning behind using DEP[F] instead of IDENT[F] is to maintain that the timing layer cannot fully rewrite segmental inputs.[43] It can only change association lines or layer features. As a result, the timing layer is expected to produce gradient phonetic outputs when the timing and metamorph layers have a mismatch (Section 2.4).

[43]The same is true of MAX as well. It is impossible for the timing layer to delete *segments*, it can only reduce slots. The expectation is for general deletion patterns to leave phonetic traces behind, as famously observed for English t/d deletion in Browman and Goldstein (1990).

In comparison, metamorph GEN has a richer set of mechanisms available, and closely resembles the grammar typically described in mainstream Optimality Theory. It may insert epenthetic segments (with no spreading), it can freely rewrite features, and assign surface correspondence relations and evaluate them with IDENT constraints.

(284) Assumptions on metamorph GEN and CON:

a. Epenthetic segments may be inserted without spreading.

b. Segments can be rewritten, violating IDENT[F].

c. Surface correspondence (e.g. BE-Ident, Kitto and de Lacy 1999, HE-Correspondence, Stanton and Zukoff 2018)

d. Markedness constraints may be indexed for particular morphemes

Crucially, metamorph CON allows markedness constraints that are indexed for particular morphemes. I assume that while morpheme boundaries are visible in the timing layer, morpheme identity is not. This is meant to include all kinds of detailed morphological information, including diacritic features, meaning, and other paradigmatic knowledge.

5.3.2 Featural assumptions

I assume that vowels always bear a DORSAL place, following Halle (2000); Howe (2004); Staroverov (2014). Additionally, I assume that languages may differ on whether high or front vowels can bear CORONAL place, and on whether round vowels bear LABIAL place. Other than this, I expect vowels to only bear DORSAL features — any other place must be inherited from surrounding consonants or inserted.

5.3.3 Sample derivations

I now walk through sample derivations in detail for consonant epenthesis in Faroese and Axininca Campa. While these two languages look similar on the surface, since they both insert consonants before vowel-initial suffixes, closer analysis reveals that they differ in their motivations and derivational paths.

5.3.3.1 Faroese: Language-general epenthesis

To give a sample derivation, consider Faroese (Lockwood, 1955; Staroverov, 2014). Faroese epenthesizes a glide between a vowel-final root and suffix with an initial high vowel, shown in (285). The glide [w] occurs after back vowels, [j] after front ones. (Low and mid vowels, as in (286), trigger no such epenthesis.)

(285) Faroese consonant epenthesis before high vowels (Lockwood 1955: 9-13)

	UR	bare	suffixed	gloss
a.	/jɔmfrʉu/]	[jɔmfrʉu]	[jɔmfrʉuw-ɪn]	‘the maiden’
b.	/bœʏ/	[bœʏ]	[bœʏj-ɪn]	‘the town’
c.	/frɛa/	[frɛa]	[frɛaj-ɪ]	‘the seed’
d.	/bøː/	[bøː]	[bøːj-ɪn]	‘the homefield’
e.	/ɔa/	[ɔa]	[ɔaj-ɪn]	‘the stream’

(286) No consonant epenthesis before non-high vowels (Staroverov 2014: 3, Lockwood 1955)

	UR	suffixed	gloss	
a.	/ʊmrøː-a/	[ʊmrøː-a]	‘discussion’	* [ʊmrøːw-a]
b.	/fo-a/]	[fo-a]	‘to obtain’	* [fow-a]
c.	/leː-a/]	[leː-a]	‘to load’	* [leːj-a]

The Faroese glide epenthesis pattern is in line with the generalizations from Section 5.2.2. The segments /w/ and /j/ are highly sonorous, which is what we expect for intervocalic epenthesis (*Loud and Proud*). The glide /w/ is also not Structure Preserving — while I will not go into detail on this here, /w/ is not robustly contrastive in Faroese, only occuring in these derived stem-medial contexts (Lockwood 1955: 16). Similar sounds, such as /j/ and /v/, contrast root-initially (e.g. [jɛa] ‘yes’, [veːva] ‘to weave’, Lockwood 1955: 17, 21). The pattern is also clearly assimilatory, where the quality of the vowel conditions the the glide.

Under Lamination Theory, Faroese glide epenthesis proceeds as follows. The suffix vowel spreads leftwards to insert a C-slot, violating *SPAWN-C.[44] I assume Faroese glides are [+HIGH, DOR, (LAB)], and so spreading is sufficient to create a fully-specified glide (satisfying HAVEPLACE, Padgett 1995). Spreading from non-high vowels cannot create a glide, because it will either violate DEP[HIGH] (as in (291), candidate c.) or create an illicit non-high glide (*GLIDE$_{[\text{-HIGH}]}$, candidate d.).

(287) ONSET: Assign a violation for any V-slot that is not immediately preceded by a C-slot. (cf. Prince and Smolensky 1993: 17)

(288) *SPAWN-C: Assign a violation for a feature that is associated with a C-slot in the output, but where the slot has no correspondent in the input.

(289) *GLIDE[-HIGH]: Assign a violation for a C-slot associated with [-CONS] that is not also associated with a [+HIGH] feature.

(290) DEP[HIGH]: Assign a violation for a feature [±HIGH] in the output that has no correspondent in the input.

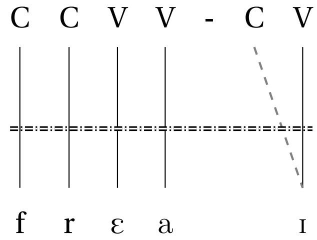
(291) a. Derivation for /frɛa-ɪ/ → [frɛaj̲-ɪ] 'the seed'

/frɛa-ɪ/	*GLIDE$_{[\text{-HIGH}]}$	DEP[HIGH]	ONSET	*SPAWN-C
a. frɛa-ɪ			*!	
☞ b. frɛa-$j_2ɪ_2$				*
c. frɛ$a_1j_{1,[+HI]}$-ɪ		*!		*
d. frɛa_2j_2-ɪ	*!			*

[44] It's also acceptable to use DEP-C, provided we assume GEN cannot create candidates with unassociated C-slots. I use the constraint *SPAWN-C primarily as a rhetorical tool to remind the reader of the limitation on GEN, but aside from this, there is no ranking that would favor DEP-C over *SPAWN-C or vice versa.

Candidate b. [frɛa-j̠ɪ]

b.



Other candidates, such as those involving vowel deletion (e.g. *[frɛa]), are ruled out with undominated *FLOAT (not shown above).

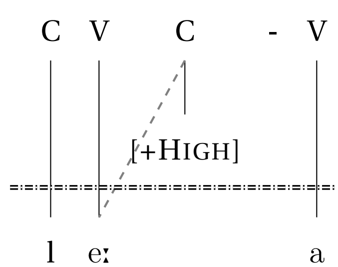
There is no glide epenthesis between two non-high vowels (e.g. /leː-a/ → [leː-a] 'to load'). This follows from the fact that feature epenthetic glides must be high, but there is no available source for a high feature — there is no high vowel to spawn a glide, and feature epenthesis is not permitted.

(292) a. Derivation for /leː-a/ → [leː-a] 'to load'

/leː-a/	*GLIDE$_{[\text{-HIGH}]}$	DEP[HIGH]	ONSET	*SPAWN-C
☞a. leː-a			*	
b. leː$_1$j$_1$-a	*!			*
c. leː$_1$j$_{1,+\text{HI}}$-a		*!		*
d. leːj$_2$-a$_2$	*!			*
e. leːj$_{2,+\text{HI}}$-a$_2$		*!		*

Candidate c. *[leː$_1$j$_1$-a]

b.



Because DEP[HIGH] outranks ONSET, Faroese will tolerate hiatus instead of epenthesizing a glide between non-high vowels. Epenthesis will only occur when it does not require feature insertion.

Later on, we'll see that other languages behave differently, where markedness outranks feature insertion. In these cases, feature insertion is *always* used, resulting in a fixed epenthetic PLACE or MANNER that is independent of the neighboring vowels. For examples of this, see Washo (Section 5.5.1.1) and Noon (Section 5.5.1.3).

5.3.3.2 Axininca Campa: Morphologically-restricted epenthesis

Axininca Campa (Apurucayali) is a famous case of /t/ epenthesis (Lombardi, 2002; McCarthy and Prince, 1993b; Payne, 1981). The standard analysis is that /t/ epenthesizes to provide an onset to the suffix syllable, as shown in (293).

(293) In vowel-final roots, vowel-initial suffixes occur with /t/ (Payne 1981: 108)

a.	/i-ŋ-koma-i/	→ i-ŋ-koma-t̲i	'he will paddle'
b.	/i-ŋ-koma-aa-i/	→ i-ŋ-koma-t̲aa-t̲i	'he will paddle again'
c.	/i-ŋ-koma-ako-i/	→ i-ŋ-koma-t̲ako-t̲i	'he will paddle for it'
d.	/i-ŋ-koma-ako-aa-iro/	→ i-ŋ-koma-t̲ako-t̲aa-t̲iro	'he will paddle for it again'

3SG-FUT-paddle-APPL-FUT-REP

(294) In consonant-final roots, only outer suffixes occur with /t/ (Payne 1981: 108)

a.	/i-ɲ-c^{h}ik-i/	→ i-ɲ-c^{h}ik-i	'he will cut'
b.	/i-ɲ-c^{h}ik-aa-i/	→ i-ɲ-c^{h}ik-aa-t̲i	'he will cut again'
c.	/i-ɲ-c^{h}ik-ako-i/	→ i-ɲ-c^{h}ik-ako-t̲i	'he will cut for it'
d.	/i-ɲ-c^{h}ik-ako-aa-iro/	→ i-ɲ-c^{h}ik-ako-t̲aa-t̲iro	'he will cut for it again'

3SG-FUT-cut-APPL-FUT-REP

Under Lamination Theory, this pattern would be problematic if fully general, because in order for /t/ to be epenthesized in the timing layer, the features [COR, +VOI, -CONT, -SON] all need to be inserted. All else being equal, epenthesis of /t/ should be harmonically bound by /g/ (or any other voiced consonant), since voiced consonants have more in common with vowels. Epenthesis of /t/ should be technically possible given the right markedness constraints, but it would require a staggering number of them.

However, Axininca Campa is not a fully general /t/ epenthesis pattern. When we look closer at the alternations, we find that there are some morphological contexts where /t/ epenthesis does not occur even where we might expect. This is significant because if Axininca Campa is morphophonological, taking place in the metamorph layer, then we have no expectations for voiceless stops to be restricted. Epenthesis should take place by segmental insertion, not spreading.

I now present some cases where t/∅ alternations do not occur, even though a general epenthesis analysis predicts it. At prefix-stem boundaries, hiatus is resolved by deleting V_1:

(295) Hiatus at prefix boundaries triggers deletion (Payne 1981: 77)

a.	/no-iŋki-ni/	→ n-iŋki-ni	'my peanut'
b.	/no-ana-ni/	→ n-ana-ni	'my black dye'
c.	/no-oŋko-ni/	→ n-oŋko-ni	'my edible plant'
d.	/no-airi-ti/	→ n-airi-ti	'my bee'
e.	/no-iirisi-ti/	→ n-iirisi-ti	'my new leaf'

(296) Prefixes to consonant-initial words show no deletion (Payne 1981: 77)

a.	/no-mapi-ni/	→ no-mapi-ni	'my rock'
b.	/no-saŋko-ni/	→ no-saŋko-ni	'my sugar cane'
c.	/no-t^{h}oŋki-ni/	→ no-t^{h}oŋki-ni	'my small ant'

At other suffix boundaries, we see the same thing: the root vowel is preserved, and the affix vowel is deleted:

(297) Hiatus at distributive suffix boundary triggers vowel deletion (Payne 1981: 45)

a.	/i-pijo-ic^{h}i-takawo/	→ i-pijo-c^{h}i-takawo	'he has gathered it, in addition'
b.	/i-pina-ic^{h}i-takawo/	→ i-pina-c^{h}i-takawo	'he has paid her, in addition'
c.	/i-tasi-ic^{h}i-takawo/	→ i-tasi-c^{h}i-takawo	'he has roasted it, in addition'

(298) Suffix vowel does not delete after consonant-final roots (Payne 1981: 45)

a.	/i-č^{h}ik-ic^{h}i-takawo/	→ i-č^{h}ik-ic^{h}i-takawo	'he has cut it, in addition'
b.	/i-t^{h}oŋk-ic^{h}i-takawo/	→ /i-t^{h}oŋk-ic^{h}i-takawo/	'he has finished it, in addition'

At other suffix boundaries, VV hiatus is tolerated and no epenthesis occurs (299), but three-vowel sequences will again trigger vowel deletion (300).

(299) Hiatus is tolerated with diminutive suffix (no epenthesis) (Payne 1981: 110)

a. /hito-iriki/ → hito-iriki ‘little spiders’ *hito-ṯiriki

b. /mapi-iriki/ → mapi-iriki ‘little rock’ *mapi-ṯiriki

c. /ana-iriki/ → ana-iriki ‘little black dye plant’ *ana-ṯiriki

(300) But even a root vowel will delete to avoid VVV (again, no epenthesis!) (Payne 1981: 141)

a. /sampaa-iriki/ → sampa-iriki ‘little balsa’

b. /c^{h}iwoo-iriki/ → c^{h}iwo-iriki ‘little cane boxes’

c. /manii-iriki/ → mani-iriki ‘little ants’

c. /no-pai-iriki/ → no-pa-iriki ‘my little grey hairs’

The data in (297)-(300) severely complicate the picture of Axininca Campa /t/ epenthesis. Hiatus at morpheme boundaries does appear to be marked, but the range of repairs goes beyond /t/ epenthesis. In other contexts, vowels are deleted instead.

I am not the first one to notice these restrictions. On the basis of similar data, Staroverov (2014: 154) and Morley (2015: 7) argue that Axininca Campa is best analyzed as deletion, not epenthesis. These analyses, however, rely on arguments of theoretical parsimony. The safer option here is to stay closer to the facts: Axininca Campa [t / ∅] alternations are not predictable based on sound alone. Based on this, Axininca Campa cannot be considered a language-general /t/ epenthesis pattern, and therefore cannot be a counterexample to *Meek and discreet*.

Here I analyze Axininca Campa /t/ epenthesis with a morphologically-indexed constraint ranking in the metamorph layer (Gouskova, 2012; Pater, 2000, 2009), ONSET$_{X}$ ≫ DEP[T]. The constraint ONSET$_{X}$ produces a violation whenever a morpheme bearing the X diacritic lacks an onset (cf. ONSET, Prince and Smolensky 1993). I assume that the TAM suffixes from (293)-(294) all bear an X diacritic, but those from (299)-(300) do not. The derivation of /i-ŋ-koma-i/ → /i-ŋ-koma-ṯi/ ‘he will paddle’ proceeds as in (301):

(301) Axininca Campa epenthesis as morphologically-driven requirement for onsets

/i-ŋ-koma-i_X/	ONSET$_X$	MAX	DEP[T]
a. i-ŋ-koma-i	*!		
☞ b. i-ŋ-koma-ti			*
c. i-ŋ-kom-i		*!	

There are two main things to note here about the output representation in (301). First, the epenthetic consonant is not derived by spreading. I connect to the fact that morphologically-restricted patterns do not have the same assimilatory bias as language-general ones, which must be derived with spreading. Second, the output consonant is indistinguishable from segments that are present in the input. Later on, this will be important for deriving the fact that morphologically-restricted patterns are Structure Preserving (Section 5.4), meaning that they generally only use sounds that are already contrastive in the language.

Suffixes that lack the x diacritic, such as the diminutive, do not undergo epenthesis because they do not violate ONSET$_X$. The derivation for /hito-iriki/ → [hito-iriki] 'little spiders' is provided in (302):

(302) Axininca Campa diminutives have no special requirement for onsets

/hito-iriki/	ONSET$_X$	MAX	DEP[T]
☞ a. hito-iriki			
b. hito-tiriki			*!
c. hit-iriki		*!	

There are several alternatives to using morphologically-indexed constraints, including Cophonologies (Inkelas and Zoll, 2007) and readjustment rules (Halle and Marantz 1994: 282). A Cophonology alternative could apply ONSET ≫ DEP[T] upon Spellout of any of the TAM suffixes from (293)-(294). Readjustment rlues would operate similarly, where upon spellout of a TAM suffix, a rule applies that inserts /t/. The difference among these theories is whether or not phonological structure is being optimized for at some level. In both the morphologically-indexed approach and Cophonologies, there is some type of marked phonological structure that is being avoided (e.g. ONSET). In readjustment rules, there is no such requirement. I leave this as an empirical question on whether there are cases of consonant epenthesis that are not phonologically optimizing.

5.3.4 Interim Summary

To summarize, Lamination Predicts that the typology of epenthetic consonants should be split into two types. When the patterns are fully general, they should be derived via spreading in the timing layer. Epenthetic consonants in the timing layer will thus always be maximally assimilatory with surrounding sounds. In morphologically restricted patterns, however, consonant epenthesis is determined via an arbitrary segmental insertion mechanism.

The rest of this paper is now dedicated to going through each of the generalizations from Section 5.2.2 in detail. I begin with Structure Preservation in Section 5.4. Sections 5.5-5.7 then discuss Loud and Proud, Meek and Discreet, and Invisible Man.

5.4 Generalization 1: Structure Preservation

In this section, I focus on an important empirical generalization about epenthetic consonants that I call *Structure Preservation*, given in (303):

(303) **STRUCTURE PRESERVATION:** Morphologically-restricted epenthesis always uses sounds that are contrastive in roots. Language-general epenthesis may introduce sounds that are not contrastive.

The observation is that in the typology of epenthetic consonants, morphologically-restricted patterns always make use of segments that in a sense already available in the language. In essence, morphologically-restricted patterns appear to use a narrowed search space when selecting epenthetic quality, only using sounds that appear in morphemes.

In comparison, language-general epenthesis patterns appear to be quite a bit freer in how they select their quality, and may produce sounds that only bear marginal status. These patterns are *non-structure preserving*, because they create sounds that only arise as the result of epenthesis. Examples of these kinds of language-general patterns will be epenthetic [g] in Amarasi (Section 5.4.1) and [w] in Tamil (Section 5.4.3). In each of these languages, these segments are *only* attested in epenthetic contexts, and are never found in roots. This inverts the expected typology, because roots generally bear more contrasts than affixes (see Beckman 1998, Gouskova 2021).

The concept of Structure Preservation more generally has its origins in Lexical Phonology (Kaisse and Shaw, 1985; Kiparsky, 1985), where lexical rules were *structure preserving*, meaning that they could only produce segments that are available as possible inputs. This behavior of morpheme-restricted epenthesis is expected under Lexical Phonology, but only by hypothesis — this property is not explained through any analytic machinery.

In this section, I demonstrate that these kinds of non-structure preserving patterns pose difficulties for two kinds of theories of epenthesis: (i) those that use splitting, and (ii) those that claim the inserted segment is the least marked. I begin by outlining some of these problems through a case study on Amarasi [g] epenthesis.

In comparison, Lamination Theory is able to handle them without much fuss, despite its intuitive similarities to Splitting Theory. I capture Structure Preservation by leveraging the representational differences between timing and metamorph layers. Since only the metamorph layer can create new atomic segments, only metamorph patterns will be restricted by constraints on entire segments. This ends up creating an effect similar to morpheme structure constraints (MSCs, Gouskova 2023; Halle 1959), but houses them within the evaluated phonological component of grammar.

5.4.1 Showcasing the problem: Amarasi

Amarasi is a language spoken in West Timor, Indonesia that epenthesizes [g] to avoid vowel hiatus across a morpheme boundary (in a variation on CRISPEDGE, see Edwards 2016; Itô and Mester 1994, 1999). The crux of the problem, which I'll demonstrate, is that /g/ is not robustly contrastive in the language, as it only appears in epenthetic contexts but never native roots or loanwords.

I present two analyses, one in Splitting Theory (Staroverov, 2014) and one in Standard Parallel OT using the Emergence of the Unmarked (McCarthy and Prince, 1994), which both run into problems accounting for the distribution of Amarasi /g/.

The Amarasi consonant inventory in shown in (304). While its inventory is small, Amarasi does contrast voicing in labial stops (e.g. [pah] 'land' vs. [bah] 'indeed') and has a voiceless velar stop (e.g. [kero] 'monkey'). This suggests that the features needed to create [g] are present in the language, and so it should be considered a gap.

(304) Amarasi consonant inventory (loanword-only in parentheses)

	Labial	Alveolar	Palatal	Velar	Glottal
Plosive	b p	t		k	ʔ
Nasal	m	n			
Fricative	f	s			h
Affricate			(dʒ)		
Liquid		r			

All consonants from (304) contrast in onset position, shown in (305). This is largely expected; most OT accounts adopt some version of positional faith, which expect contrasts to be maximized in roots, onsets, and morpheme initial position (Beckman, 1998; Gouskova, 2021; Steriade, 1994).

(305)

[boʔ] 'ten'	[poʔon] 'orchard'	[toʔo] 'angry'	[ʔoo] 'k.o. bamboo'
[meo] 'cat'	[peo] 'onion'	[neo] 'to'	[reok] 'good (medial)'
[fai] 'night'	[hai] '1PL.NOM'	[ʔai] 'fire'	[kai] '1PL.ACC'
[roit] 'money'	[toit] 'ask'	[soiʔ] 'count'	

It is therefore surprising that no words (roots or otherwise) begin with /g/. In loanwords that do have initial /g/, it is realized unfaithfully as [k], shown in (306).

(306) Amarasi adapts loanword /ɡ/ as [k]

	Amarasi	Indonesian	gloss	
a.	krei	geredʒa	'church'	(via Portuguese *igreja*)
b.	kuru	guru	'teacher'	(via Sanskrit *guru*)

The standard way to handle these kinds of facts in OT is to rank markedness over faith, in this case *ɡ ≫ IDENT[VOI]. Thus, even in a Rich Base and loanwords, input /ɡ/ is mapped to [k].

However, this initial analysis runs into complications once we consider consonant epenthesis. At morpheme boundaries, Amarasi epenthesizes /ɡ/ to avoid vowel hiatus, as in (307). When there is no vowel hiatus, there is no epenthesis, as in (308).

(307) Amarasi (Oekabiti) consonant epenthesis

a.	/meo-e/	→ [meog-e]	'the cat'	cf. [meo]	'cat'
b.	/ʔao-es/	→ [ʔaog-es]	'a body'	[ʔao]	'body'
c.	/noe-es/	→ [noeg-es]	'a river'	[noe]	'river'
d.	/tasi-e/	→ taisg-e	'the sea'	tasi	'sea'
e.	/roti-e/	→ roitg-e	'the bread'	roti	'bread'

(308) When there is no vowel hiatus, no consonant epenthesis occurs

a.	/noah-es/	→ [noah-es]	'a coconut'	cf. [noah]	'coconut'
b.	/tai-s-e/	→ [tai-s-e]	'the sarong'	[tai-s]	'sarong'
c.	/loi-t-e/	→ [loi-t-e]	'the money'	[loit]	'money'
d.	/kokɪs-e/	→ [koɪks-e]	'the bread'	[kokɪs]	'bread'
e.	/manus-es/	→ [mauns-es]	'a betel vine'	[manus]	'betel vine'

An argument that this segment is truly epenthetic (and not deletion) comes from plural allomorphy. The plural suffix has three phonologically-conditioned allomorphs in Amarasi: *-in* (after consonants), *-n* (after singleton vowels), and *-nu(k)* (after two vowels). If the consonants in (307) were underlying rather than epenthetic, we would expect for them to uniformly take *-in*. In (309), we see that these forms do take *-in*, as expected for vowel-final stems.

(309) Plural has phonologically-conditioned allomorphy:

	-*n* after V# words			-*in* after C# words	
a.	[ʔasu-n]	'dogs'	f.	[noah-in]	'coconuts'
b.	[fatu-n]	'stones'	g.	[tais-in]	'sarongs'
c.	[kero-n]	'monkeys'	h.	[loit-in]	'(kinds of) money'
d.	[nafnafɪ-n]	'spiders'	i.	[koɪks-in]	'cakes'
e.	[tasi-n]	'seas'	j.	[mauns-in]	'betel vines'

In comparison, a deletion alternative would state that all forms that take [-n] 'PL' are /g/-final, and that the /g/ is deleted after allomorph selection. That said, cross-dialectal evidence in Meto supports the epenthesis analysis: in Amanuban, which transparently epenthesizes glides (e.g. [meow-e] 'the cat', [fatuw-e] 'the stone', we have the same allomorphy pattern.

To review, the distribution of /g/ is gapped. It only occurs word-medially, never in word-initial position. In comparison, /k/ is found faithfully in every position where consonants can occur in Amarasi. (Word-final consonant clusters are not permitted.)

(310) /k/ is realized faithfully in every position

#kV	#kC	#Ck
kiso 'see'	kninuʔ 'clean'	nkius 'he sees'
kero 'monkey'	kbitiʔ 'scorpion'	bkaʔu 'bat'
VkV	VkCV	Vk#
kokɪs 'bread'	raokneke 'cassava'	hunik 'turmeric'
bikaseʔ 'horse'	korokrei 'sparrow'	ʔutak 'vegetable'

I now demonstrate that these facts present a thorny analytical issue for both Splitting Theory and the Emergence of the Unmarked. I then present an analysis in Lamination Theory, which uses its enriched representations to derive this pattern.

5.4.1.1 Amarasi and Splitting Theory

First, let's consider an analysis of this in Splitting Theory (Staroverov, 2014), which derives epenthetic consonants from vowels that violate INTEGRITY and IDENT. The loanword facts are simple: we rank *g over IDENT[VOI]. When we turn to the epenthesis cases, however, we face a problem: we need /g/ to be permitted in word-medial contexts so that we derive [meog-e] and not [meok-e]. This is not simple to rule out. One possibility is to have a simple V[-voi,+cons]V constraint, which penalizes voiceless stops between two vowels. The problem is that this favors unfaithful mappings of /k/ in word medial positions, such as /kokɪs/ 'bread' to *[kogɪs].

(311) Problems with *g in Amarasi

		*V-V	INTEGRITY	V[-VOI, +CONS]V	*g	IDENT[VOI]
/guru/	a. guru				*!	
	☞ b. kuru					*
/meo-e/	a. meo-e	*!				
	☞ b. meo_1g_1-e		*		*	
	c. meo_1k_1-e		*	*!		
/kokɪs/	☹a. kokɪs		*!			
	💣b. kogɪs				*	*

A workaround to this problem is to use constraint conjunction (Smolensky, 1995) to allow no simultaneous violations of IDENT[VOI] and IDENT[CONS]. Candidates like [meo_1k_1-e] would incur a violation, but [kuru] would not.

The solution, however, casts the Amarasi situation as a unique problem. It is an accident that /g/ happens to be gapped in the inventory, and has no bearing on the analysis or representation of these epenthetic consonants. As we will see in Section 5.4, there is reason to believe Amarasi is *not* unique: several other languages like this exist, including Faroese (Lockwood, 1955; Staroverov, 2014), German (Steriade, 2001), Koryak (Kenstowicz, 1976; Kurebito, 2004; Lombardi, 2002), and Tamil (Christdas, 1988). The Splitting Analysis, while capable of capturing the facts, misses a generalization.

5.4.1.2 Amarasi and the Emergence of the Unmarked

Theories that cast epenthetic segments as the least marked segments also run into problems with Amarasi (the Emergence of the Unmarked, Lombardi 2002; McCarthy and Prince 1994). At first, the situation appears simple: we rank *g high, giving the ranking *V-V ≫ Dep, and *g ≫ Ident[Voi], as in (312):

(312)

		*V-V	Dep	*g	Ident[Voi]
/guru/	a. guru			*!	
	☞ b. kuru				*
/meo-e/	a. meo-e	*!			
	☞ b. meo$_1$g$_1$-e		*	*	
/kokɪs/	☞ a. kokɪs				
	b. kogɪs			*!	*

At first, all appears well. But, a problem appears when we consider why /g/ appears as opposed to any other consonant. For instance, labial consonants do have a voicing contrast, and so *b (and *p) must be ranked *below* Ident[Voi] in Amarasi (otherwise we would predict neutralization of voice in labials). However, this ranking predicts that /b/ should be epenthetic, not /g/:

(313)

		*g	Dep	Ident[Voi]	*b
/bah/	☞ a. bah				*
	b. pah			*!	
/meo-e/	☹ a. meog-e	*!	*		
	💣 b. meob-e		*		*

Again, there are several ways around this. We could offer Dep constraints that are specified for each segment, as in Steriade (2001). In this case, Dep[k], Dep[p], and Dep[k] would all outrank Dep[g]. The fact that /g/ is a gap does not matter — as long as the other Dep constraints outrank *g, /g/ will be inserted regardless of the cost to markedness.

However, this kind of approach severely weakens the predictive power of the theory. Recall, these Emergence of the Unmarked theories claim that the typology is restricted by hierarchies of markedness intersecting with faith. If we have these segment-based DEP constraints, then the question remains: what restricts their ability to be reranked from language to language? Perceptibility is one such option, as Steriade suggests. That said, this adjustment constitutes a serious revision to the theory, as it no longer considers markedness a primary factor in determining epenthetic quality.

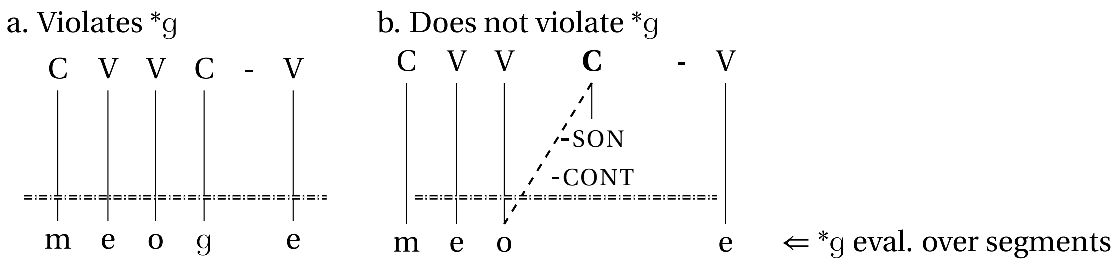
5.4.2 Analysis: Amarasi in Lamination Theory

To review, Amarasi produces epenthetic segments that are not contrastive in the language, and under standard OT analyses, should be quite marked. However, if [g] is marked, then it should be the worst possible epenthetic consonant in the language — any other phoneme of the language should be preferable.

Lamination Theory is able to resolve this issue. In Lamination Theory, there is a representational difference between segments (which represent the underlying contrasts available in the language) and the surface sounds realizing those features (which follow how features, both in segments and those individually layered, are associated with timing slots). It is therefore possible to create a version of a *g constraint that only cares about segments, but not surface sounds that realize those features from multiple sources.

To illustrate, in Amarasi we can define a constraint against segments of the shape [DOR, -CONT, -SON], shown in (314). Forms like (315a.) violate this *g constraint, because the bundle [DOR, -CONT, -SON] is present. By contrast, the epenthetic segment in (315b.) does not violate *g, because the epenthetic [-SON] and [-CONT] features do not form a single segment with [DOR].

(314) *g: Assign a violation for a segment [DOR, -CONT, -SON] that is associated with a C timing slot.

(315) 

So, while /g/ is not possible as a segment, it is possible as an output of the timing layer. This ends up operating similar to a Morpheme Structure Constraint, which I'll discuss soon, but with the difference that it is in the main phonological derivation.

To illustrate, see the derivation for [meog-e] in (318) below. Glides are ruled out through the cover constraint *GLIDE. Meanwhile, DEP[CONT] and DEP[SON] are dominated, and so [-SON,-CONT] are both inserted.

(316) *V-V: Assign a violation for a sequence of two V slots separated only by a morpheme boundary.

(317) *GLIDE: Assign a violation for a C-slot that is [-CONS, +CONT].

(318)

/meo-e/	*V-V	*GLIDE	*FLOAT	*SPAWN-C	DEP[CONT,SON]
a. meo-e	*!				
b. meo_1w_1-e		*!			
c. meo-			*!		
☞ d. $meo_1g_{1,\text{-SON},\text{-CONT}}$-e				*	**

The reason why /g/ arises over other consonants follows from the fact that Amarasi (nor any dialect of Meto, for that matter) does not allow insertion of PLACE features. Amarasi vowels only bear [DORSAL] place (other distinctions are made with vowel-specific features, like [±HIGH]). Epenthetic /g/ preserves that place while inserting minimal features.

(319)

/meo-e/	DEP[+C.G.]	DEP[NAS]	DEP[LAT]	DEP[SON]	DEP[CONT]
a. $meo_1ʔ_1$-e	*!				*
b. $meo_1ŋ_1$-e		*!			*
c. $meo_1ʀ_1$-e			*!		
☞ d. $meo_1ɡ_1$-e				*	*

There is a good question here of exactly what these different DEP[F] rankings represent. One possible option is that they are a representation of articulatory effort (Kirchner, 2001). Another is that they are related to perceptibility (Steriade, 2001), with less-perceptible features being easier to insert. I discuss these possibilities in Section 5.8.2.

For loanwords, the reasoning here is that *ɡ in Amarasi will induce loanword adaptation in the metamorph layer. Forms like /ɡuru/ or /ɡeredʒa/ violate *ɡ, and so IDENT[VOICE] is violated to transform these into [k]. The representational differences between the timing and metamorph layers thus allow us to capture why /ɡ/ is impossible in morphemes, but acceptable as an epenthetic segment.

The clearest analogue to the *ɡ in Lamination Theory are morpheme structure constraints. Morpheme structure constraints are an old idea in phonology (see Halle 1959; Stanley 1967), and were proposed as a way to constrain the possible phonological forms of morphemes. In early generative work, morpheme structure constraints were criticized on the grounds that they introduce duplication into the theory (Clayton 1976; Kenstowicz and Kisseberth 1977; Paster 2013; Shibatani 1973), since it allows constraints to be stated over both lexical entries and surface forms. With the advent of constraint-based frameworks, MSCs fell into disuse (McCarthy 2002: 71).

However, recent work has challenged the idea that MSCs are not worth the perceived cost to theoretical parsimony (Gouskova, 2023; Paster, 2013). For instance, Gouskova (2023) argues in favor of MSCs based on the distribution of [dʒ] in Russian. The observation is that no morphemes bear underlying /dʒ/ in the language, including loanwords where we might expect it, and yet [dʒ] can be produced by voicing assimilation. Gouskova demonstrates that the gapped distribution of [dʒ] cannot avoid duplication: either in the form of an MSC, or in the form of multiple constraints on *[dʒ], one ends up stating similar constraints twice.

In Lamination Theory, metamorph layer constraints are analogous to MSCs, as they also narrow the kinds of underlying contrasts permitted in a language. However, they are not identical. One core purpose of the metamorph layer is to fix precedence relations in a way that cannot be changed. The segments in the metamorph layer (their identity, their order) are a persistent part of the phonological representation and are frequently referenced. MSCs, in comparison, are applied once to the lexicon and then have no further role in the derivation. Indeed, Gouskova (2023) even argues that MSCs like *dʒ in Russian cannot interact with faith, which is responsible for speaker variability in how loanwords are adapted.

This leads to the second difference: in Lamination Theory, *g is ranked within the phonological grammar. (Whether or not *g is ranked in the timing layer or metamorph layer could be up for debate, but *g must be ranked with respect to faith.) MSCs, depending on their implementation, need not be.

5.4.3 Other languages with Non-Structure Preserving patterns

There are several other languages that also have non-structure preserving epenthesis patterns, including Tamil, Koryak (Kenstowicz, 1976; Lombardi, 2002), German (Steriade, 2001) and Faroese (Lockwood, 1955; Staroverov, 2014). I briefly discuss Tamil here. Again, the the reason these patterns are of interest is how they interact with theories of markedness. If inventory gaps are generated by high-ranked markedness, and epenthetic segments occupy those gaps, then we need a theory that does not rely only on surface markedness in a flat representational structure to explain epenthetic quality.

To illustrate, consider Tamil (Christdas, 1988), which also has a non-structure preserving epenthesis pattern, where /w/ is inserted despite the /w/ otherwise being absent from the language.

The Tamil inventory is shown in (320) below:

(320) Tamil consonant inventory (Keane, 2004)

	Bilabial	Labio-dental	Dental	Alveolar	Post-alveolar	Retroflex	Palatal	Velar
Plosive	p (b)		t̪ (d̪)			ʈ (ɖ)		k (g)
Affricate					tʃ (dʒ)			
Nasal	m			n		ɳ	(ɲ)	
Fricative				s				
Tap				ɾ				
Approximant		ʋ				ɻ	j	
Lateral approximant				l		ɭ		

Tamil uses consonant epenthesis to avoid vowel-initial words. Glottal stops are inserted before low vowels (321a.), [j] before high vowels (321b.), and [w] before round vowels (321c.).

(321) Tamil consonant epenthesis prevents vowel-initial words (Christdas 1988: 164)

a.	/aːcaj/	→ ʔaːcɜ	'desire, hope'	cf.	peːr-aːcɜ	'greed'
b.	/iruʈʈ/	→ jiruʈʈɯ	'darkness'		kuʈʈ-irɯʈʈɯ	'pitch dark'
	/eɻump/	→ jeɻɯmbɯ	'ant'		kaʈʈ-eɻɯmbɯ	'a kind of ant'
c.	/oʈʈakam/	→ woʈʈɜxã	'camel'		poɳɳ-oʈʈɜxã	'golden camel'
	/uːsij/	→ wuːsi	'needle'		kuɳɖ-uːsi	'pin'

Crucially, neither [w] or [ʔ] are phonemic in the language, and only surface in this limited context.

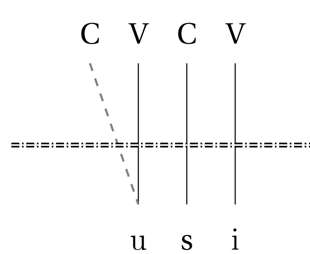
In Lamination Theory, the glide epenthesis pattern is analyzed as spreading. The vowel spreads leftwards to a C-slot, producing [j, w] from the vowel segment.

(322) Tamil glide epenthesis arises via spreading

Derivation of /uusi/ → [wuːsi] 'needle'

/uːsi/	ONSET	DEP[+C.G.]	*SPAWN-C
a. uːsi	*!		
☞b. wuːsi			*
c. ʔuːsi		*!	

Candidate b. [wuusi]



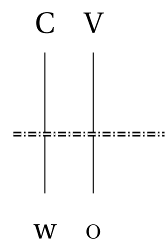
The reason why Tamil permits epenthetic [w] but not underlying [w] follows from constraints on segments. I introduce the constraint *w, which militates against [Lab, -cons] segments that are only associated with a C-slot. The *w constraint prohibits [w] in non-epenthesis contexts, but allows [w] as a result of epenthetic spreading.

(323) *w: Assign a violation for a [Lab, -cons] segment that is only associated with a C-slot.

(324) Underlying /w/ violates *w (nonce example)

/wo/	Onset	*w	Ident[Cons]
a. wo		*!	
☞b. ʋo			*

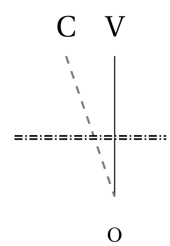
Candidate a. wo violates *w



(325) Epenthesis does not violate *w (nonce example)

/o/	Onset	*w	*Spawn-C
a. o	*!		
b. wo			*

Candidate b. [wo] does not violate *w



The glottal epenthesis pattern also proceeds straightforwardly, but makes use of feature insertion instead of spreading. Low glides are prohibited on the surface[45], and so the only way to make an acceptable epenthetic consonant is to insert features.

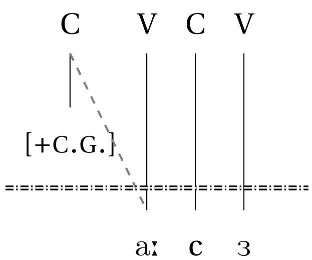
[45] As in Faroese, see Section 5.3.3.1.

(326) Glottal stops are epenthesized as an alternative to low glides

Derivation of /aːcaj/ → [ʔaːcɜ] ‘desire, hope’

/aːcaj/	ONSET	*LOWGLIDE	DEP[+C.G.]	*SPAWN-C
a. aːcɜ	*!			
b. $j_{[+LOW]}$aːcɜ		*!		*
☞c. ʔaːcɜ			*	*

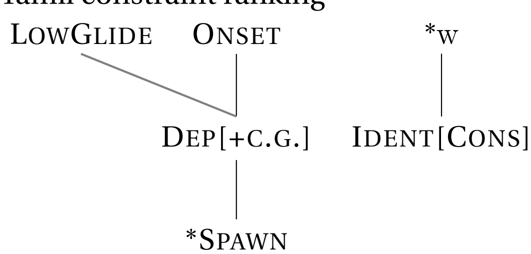
Candidate c. [ʔaːcɜ]



Again, underlying glottal stops are prohibited through constraints against segments containing [+C.G.]. Since the inserted [+C.G.] feature in (326c.) is not inside a segment, it does not incur a violation of this constraint.

I summarize the core ranking for Tamil in (327) below:

(327) Tamil constraint ranking



5.4.4 Interim summary

In this section, I reviewed data that showed an interesting interaction between epenthetic quality and gapped inventories. In several languages, epenthetic segments adopt a quality that is not only marginal in the language, but is by several diagnostics expected to be quite marked. I demonstrate that Splitting Theory and markedness-based theories struggle to account for these patterns, and argue that these patterns are not exceptional, but part of a recognizable phonological effect. Language-general patterns can be non-structure preserving, but morphologically-restricted ones cannot be.

Lamination Theory offers a solution on how to translate the intuitions on structure preservation into an OT grammar. Through the different representational layers, we are able to distinguish between the set of underlying contrasts available in a language, and the availability of surface sounds bearing those features. Because these representational layers are never collapsed, it becomes possible to state persistent constraints on what is contrastive versus what is pronounceable.

5.5 Generalization 2: Loud and Proud

This section is dedicated to the generalization that I call Loud and Proud, reproduced in (328). In intervocalic contexts, epenthetic consonants tend to be sonorants:

(328) **LOUD AND PROUD:** In language-general patterns, epenthetic consonants in intervocalic positions are most often sonorants.

In Lamination Theory, language-general epenthetic consonants are derived through a combination of spreading and feature insertion. Epenthesis that transparently assimilates with surrounding sounds is expected (329a.), and default epenthesis only occurs when PLACE features are inserted (329b.).

(329)

a. Assimilatory epenthesis: spreading only   b. Default epenthesis: spreading + insertion

/du-o/ → [duw-o]   /du-o/ → [dul-o]

Languages are free to use a combination of these strategies, spreading what they can and inserting what they need.

Loud and Proud follows from the fact that epenthetic C slots can only be projected via spreading. In any language where epenthesis occurs, then either *SPAWN-C or *SPR-CTOC must be dominated, meaning that epenthetic segments will share as many features as possible with surrounding sounds.

For epenthesis in intervocalic contexts, the predicted typology is one that can be divided into five classes, which go from most likely to be epenthetic to least likely: (i) glides, (ii) glottals, (iii) liquids, (iv) nasals and voiced obstruents, and (v) voiceless obstruents. These classes correspond to the number of manner features that need to be inserted to create these epenthetic segments from vowels. As the number of inserted features increases, the likelihood of it arising as an epenthetic segment decreases. This is schematized in (330):

(330) Predicted typology of epenthetic consonants in intervocalic positions

	More similar to vowels (more likely epenthetic)							Less similar to vowels (less likely epenthetic)
			[+CONS]					
					[-SON]			
		[±S.G./C.G.]	[±LAT]	[+NAS]			[-VOI]	
				[-CONT]	[±STR]	[-CONT]	[±STR]	[-CONT]
[LAB]				m	v, β	b	f	p
[COR]			r, ɾ, l	n	z, ð	d	s, θ	t
[COR,DOR]	j			ɲ	ʐ, ʒ	ɟ	ʂ, ʃ	ç
[DOR]			ʎ, ʀ	ŋ	ɣ	g	x	k
[LAB, DOR]	w							
none		h, ʔ						
# features inserted (other than PLACE)	0	1	2	3	3	3	4	4

We can recast the *Loud and Proud* generalization in analytic terms: when more kinds of features must be inserted, as opposed to borrowed from nearby segments, the less likely the pattern is to be attested.

All else being equal, we expect for voiced obstruents to be preferred over voiceless obstruents in hiatus contexts. Voiceless obstruents require insertion of an additional DEP[-VOI] feature, and so the voiced obstruents should harmonically bound these candidates:

(331) Epenthetic voiced obstruents harmonically bound voiceless ones

	DEP[CONS]	DEP[SON]	DEP[CONT]	DEP[VOI]	total vio.
a. voiced obstruent	*	*	*		3
b. voiceless obstruent	*	*	*	*!	4

Similarly, glides should harmonically bound glottals (332b.), liquids (332c.), and nasals (332d.).

(332) Epenthetic voiced obstruents harmonically bound voiceless ones

	DEP[±C.G./S.G.]	DEP[CONS]	DEP[LAT]	DEP[NAS]	DEP[CONT]	total vio.
a. glides						0
b. glottals	*					1
c. liquids		*	*			2
d. nasals		*		*	*	3

In the typological survey (Section 5.2.1), this prediction was borne out. In intervocalic contexts, glides and glottals were by far the most common, with liquids and voiced obstruents coming next. But, in consonant-adjacent positions, obstruents and nasals were the most common.

Data from the typological survey is presented in Figure 5.2, showing the number of languages found with each epenthetic quality.[46] In the three rightmost columns, I show how many of these patterns occurred only in intervocalic contexts (V_V), adjacent to just one vowel (#V or V#), or adjacent to a consonant (_C / C_). As one moves down the chart from top to bottom, the number of languages in the intervocalic (V_V) context decreases and those in the consonant-adjacent contexts increase.

[46] This is based on 31 consonant epenthesis patterns from 23 language families (see Section 5.2.1). Note that the summed numbers do not equal 31 because some languages allowed multiple qualities. Data from the meta-review is not included here, because detailed information was not available for all languages on whether a given pattern was language-general or morphologically restricted.

Quality		# lgs. with segment	V_V	#_V / V_#	_C /C_
Glides		16			
	w	4	4		
	j	12	11	1	
Glottals		11			
	h	2	1		1
	ʔ	10	6	4	
Liquids		1			
	r	1	1		
Nasals		4			
	m	2			2
	n	1			1
	ŋ	1		1	
Voiced obstruents		7			
	b	2			2
	d	1			1
	ɣ	1	1		
	g	3	2		1
Voiceless obstruents		9			
	p	3			3
	t	3			3
	x	1		1	
	k	2			2

Figure 5.2: Counts of different epenthetic qualities from the typological survey, along with their conditioning environment in intervocalic contexts (V_V) or various kinds of margins (#_V / V_# and _C /C_.). The gray cells are just for readability to highlight the column context these segments occur in.

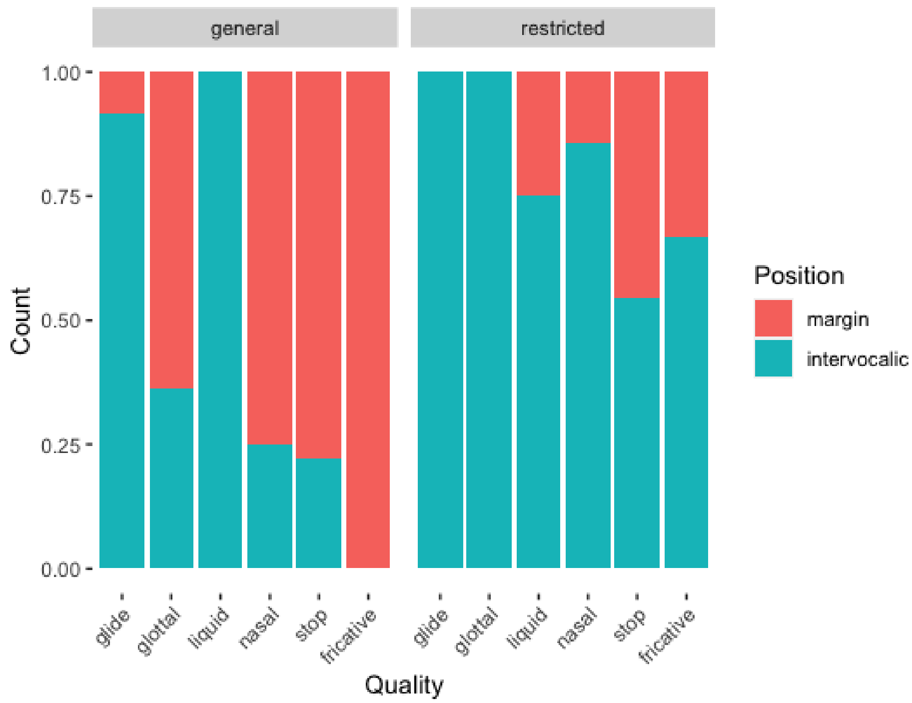


Figure 5.3: Language-general patterns insert sonorants in intervocalic contexts, obstruents in marginal contexts. Morpheme-restricted epenthesis is often intervocalic regardless of quality.

The same data is presented in Figure 5.3, with an added comparison between language-general and morpheme-restricted patterns. In the left facet, we see that language-general epenthesis tends to use glides, glottals, and liquids in intervocalic positions. In marginal positions (here taken to mean at the edge of a word, consonant-adjacent, or both), obstruents are much more common. (This is the same conclusion as Figure 5.2.) In the right facet, Figure 5.3 shows that morpheme-restricted patterns are different: intervocalic epenthesis is more common in general, and while obstruents are still more common in margins, the effect is not as strong.

The Loud and Proud generalization therefore holds. In vowel-adjacent positions, sonorants are the most common epenthetic segments. Voiceless stops, while attested in language-general patterns, only arise when they are adjacent to another consonant.

It's worth noting that this predicted typology is similar, though not identical, to that of Staroverov (2014). Staroverov's theory also predicts that epenthetic consonants will be more vowel-like, but there is no feature insertion mechanism, and so it should be *impossible* to have languages that epenthesize segments that differ in place from surrounding vowels. By contrast, my analysis allows such epenthetic qualities, but simply makes it costly.

5.5.1 Case Studies: Loud and Proud

In this section, I provide examples of the patterns summarized above (Sections 5.5.1.1-5.5.1.4). After this, in Section 5.5.1.5 I turn to voiceless obstruents, and contend that voiceless obstruents can never occur intervocalically as part of a language-general epenthesis patterns. Epenthetic voiceless obstruents, when they appear, only can occur next to a consonant or in a morphologically-restricted pattern.

5.5.1.1 Glides and glottals

The vast majority of epenthetic consonants are either glides or glottal consonants, such as [h, ʔ]. For example, in Sinhala, nouns resolve vowel hiatus by epenthesizing a glide (Smith 2001). Sinhala inserts [j] after front vowels (333a.), and [w] after other vowels (333b.). No epenthesis occurs in consonant-final words (333c.)

(333) Sinhala inserts [j, w] to avoid onsetless suffixes (Smith 2001: 63, Chandralal 2010: 91)

a.	/ræ-a/	→ ræ-ja	‘the night’	cf.	ræ-ta	’night-DAT’
	/toppi-a/	→ toppi-ja	‘the hat’		toppi	‘hats’
	/gæni-ek/	→ gæni-jek	‘a woman’		gæni-ge	‘woman-GEN’
b.	/maduru-ek/	→ maduru-wek	‘a mosquito’		maduru	‘mosquito’
	/balla-a/	→ balla-wa	‘the dog’		balla	‘dog’
	/daru-o/	→ daru-wo	‘children’		daru	‘child’
c.	/gas-a/	→ gas-a	‘the tree’		gas	‘trees’
	/den-a/	→ den-a	‘the cow’		den	‘cow’
	/radʒəj-a	→ radʒəj-a	‘government’			*radʒəj-wa

In Misantla Totonac, glottal stops are used instead of glides. They occur before vowel-initial words (334a.) and between vowels at morpheme boundaries (334b.).

(334) Misantla Totonac inserts glottal stops word-initially and medially (MacKay 1994: 382)

a. /ik-a̰n/ → ʔika̰n 'I go'

/ut uhu/ → ʔṵt ʔɔ̰hɔ́ 's/he coughs'

b. /ut laka-a̰n/ → ʔut laka-ʔa̰n 'she faces in that direction' (cf. [ʔikan] above)

/naa-utun/ → naa-ʔutun 'also they/them'

In Mabalay Atayal, we see a similar situation, but with a different conditioning environment. Glottal stops are epenthesized at the ends of words (335a.), but not in word-medial positions (335b.):

(335) Mabalay Atayal epenthesizes word-final glottal stop (Lambert 1999: 86, Staroverov 2014: 134)

a. /⟨an⟩βakɦa/ → β⟨an⟩akɦaʔ 'break (pfv)'

/⟨am⟩satu/ → s⟨am⟩atuʔ 'send (intrans)'

/⟨am⟩ktri/ → k⟨am⟩tariʔ 'kneel (intrans)'

b. /βakɦa-un/ → βakɦaun 'break (intrans.patient)'

/satu-an/ → satuan 'send (trans.loc)'

/⟨in⟩ktri-un/ → k⟨in⟩tariun 'kneel (pfv,trans.loc)'

Kalinga uses a mixture of glides and glottal stops to avoid vowel-initial words (Geiser 1970: 61, Rosenthall 1994: 237). A glottal stop is inserted between two low vowels (336a.), but glides are inserted elsewhere (336b.-336c.).

(336) Kalinga consonant epenthesis in hiatus environments (Geiser 1970: 61)

	UR	bare form	suffixed form	gloss
a.	/ʔala/	ʔala	ʔala-ʔan	'to do, follow (as teaching)'
	/pija/	pija	pija-ʔon	'to like'
b.	/daŋli/	daŋli	daŋli-jan	'to bevel'
	/dabbi/	dabbi	dabbi-jon	'to construct with dabbi'
c.	/ʔadagu/	ʔadaˈgu	ʔadagu-ˈwan	'to have pity'
	/punu/	ponu	punu-won	'to fill'

Even among these mixed glottal stop-glide languages, languages differ on how they divide up the phonological space for each epenthetic segment. In Karo Batak, for instance, a glottal stop is inserted between two identical vowels (337a.), but glides are optionally inserted otherwise (337b.-c.).[47]

(337) Karo Batak consonant epenthesis in hiatus environments (Woolams 1996: 29)

a.	/bide e/	bide ʔe		'that fence'
	/adi ipakenndu/	adi ʔipakenndu		'if you use'
b.	/ibas doni enda/	ibas doni jenda	~ ibas doni enda	'in this world'
	/sea/	seja	~ sea	'not'
c.	/dibəru e/	dibəru we	~ dibəru e	'that woman'
	/doah/	dowah	~ doah	'to carry child in sling'

In other languages, the set of glides is more restricted. Washo is one example, which epenthesizes [j] word-medially to avoid vowel hiatus across a morpheme boundary. (Washo also has word-initial epenthesis of glottals, which are discussed in Section 5.7.) Crucially, the quality of the glide is fixed. The glide will be [j] regardless of the quality of the surrounding vowels.

(338) Washo epenthesizes [j] to prevent vowel hiatus at morpheme boundaries (Staroverov 2016: 474)

Locative /-a/					
a.	/wat'a-a/ river-LOC	wat'a-ja	'in the river'	wat'a	'river'
b.	/di-dok'o-a/ 1-heel-LOC	di-dok'o-ja	'at my heel'	di'dok'o	'my heel'
c.	/laːdu-a/ 1.hand-LOC	laːdu-ja	'in my hand'	laːdu	'my hand'
Negation /-eːs/					
d.	/∅-k'eʃe-eːs-i/ 3s-alive-NEG-IMPF	∅-k'eʃe-jeːs-i	'He's dead'	ge-k'eʃe-ha	'Keep him alive!'
Imperfective /-i/					
e.	/l-emts'i-i/ 1PL-awake-IMPF	l-emts'i-ji	'I'm awake'	g-emts'i-ha	'Wake him up!'
f.	/∅-p'ɨl'ɨ-i/ 3s-fish-IMPF	∅-p'ɨl'ɨ-ji	'He's fishing'	ge-p'ɨl'ɨ	'Fish!'

[47] This pattern contrasts with Kalinga. Kalinga would treat /doah/ (337c.) as [doʔah], rather than Karo Batak [dowah].

(339) Locatives (a.), negation (b.) and imperfective suffixes (c.) have no glide in C# words

a.	/l-aŋal-a/ 1sg-house-LOC	l-aŋal-a	'on/at my house'	*l-aŋal-j̲a
b.	/∅-iːbiʔ-eːs-i/ 3PL-come-NEG-IMPF	∅-iːbiʔ-eːs-i	'They have not come'	*∅-iːbiʔ-j̲eːs-i
c.	/∅-iʃm-i/ 3SG-sing-IMPF	ʔiʃm-i	'He is singing'	*ʔiʃm-j̲i

Note that this cannot be simply analyzed as deletion – Washo allows word-medial clusters with glides (e.g. [ʔitjewsiw] 'ski', [dam'u'k'ajk'aj] 'mosquito', [gebejdi] 'He is combing him'), and so it is unlikely that the glide in (338) is present in the input.

Languages with glide or glottal epenthesis are numerous. In the meta-review and grammar survey, there 31 languages had glide epenthesis, including Ao (Gowda 1975: 23-24), Doromu-Koki (Bradshaw 2012: 39), Ilokano (Hayes & Abad 1989), Polish (Rubach 2000: 291), and Woleian (Sohn 1971, 1975). Glottal epenthesis occurs in another 52 languages, such as Wandala (Frajzyngier 2012: 61), Bambassi (Ahland 2012: 58), Bulgarian (Rubach 2000: 287), Huariapano (Parker 1994), Kisar (Christensen & Christensen 1992), Onondaga (Chafe 1970), and Xincan (Rogers 2010: 125),. Another 19 languages epenthesize either glides or glottals depending on the context, which includes Tamil (Christdas 1988), Somali (Saeed 1999: 26), and Totonac (McFarland 2009: 37-39). Together, languages with at least one glide or glottal epenthetic segment constitute 63.9% of language-general patterns (Primary source survey: 23/36).

5.5.1.2 Liquids

Epenthesis of liquids is also attested, though less common than glides and glottals. For example, in Boston English (as well as SE British dialects), we find insertion of /ɹ/ at morpheme boundaries with vowel hiatus (Vennemann 1972, McCarthy 1993, Harris 1994, Gick 1999, Orgun 2001, Uffmann 2007).

(340) Boston English ɹ-insertion (Uffmann 2007: 452)

a.	/ɪndia ənd pɑkɪstɑn/	→ ɪndia ɹ̱ənd pɑkɪstɑn	‘India and Pakistan’
b.	/ðə ʃɑː əv pɚʒə/	→ ðə ʃɑː ɹ̱əv pɚʒə	‘the Shah of Persia’
c.	/lɔː ənd/	→ lɔː ɹ̱ənd	‘law and’
d.	/spɑː ɪz/	→ spɑː ɹ̱ɪz	‘spa is’
e.	/lɔː ɪz/	→ lɔː ɹ̱ɪz	‘law is’

A similar pattern is found in Bristol English, but with insertion of /ɫ/ following word-final schwas (Wells 1982, Gick 1999). This is shown in (341):

(341) Bristol English inserts [ɫ] after word-final schwa (Wells 1982: 344)

a.	/aɪdiə/	→ aɪdiəɫ̱	‘idea’
b.	/ɛːɹjə/	→ ɛːɹjəɫ̱	‘area’
c.	/mɔnɪkə/	→ mɔnɪkəɫ̱	‘Monica’
d.	/aɪdə/	→ aɪdəɫ̱	‘Ida’

Liquid epenthesis is also attested outside of English. For instance, in the Amfo’an dialect of Uab Meto (Culhane 2018), [l] is epenthesized after [ɛ] in phrase-final position (342) or when vowel hiatus would occur at a morpheme boundary (343).

(342) Amfo’an inserts [l] after phrase-final /ɛ/ (Culhane 2018: 34)

a.	/bifɛɛ/	→ bifɛɛḻ	‘woman’
b.	/flaʔɛ/	→ flaʔɛḻ	‘coals’
c.	/nopɛ/	→ nopɛḻ	‘clouds’
d.	/kɛɛ/	→ kɛɛḻ	‘turtle’
e.	/umɛ/	→ umɛḻ	‘house’
f.	/tɛɛ/	→ tɛɛḻ	‘tea (Malay loan: [tɛh])’

(343) Amfo’an also inserts [l] to prevent hiatus across morpheme boundaries (Culhane 2018)

a.	/oɛ-ɛɛ/	→ oɛḻ-ɛɛ	‘the water’	cf. noah-ɛɛ	‘the coconut’
b.	/noɛ-ɛɛs/	→ noɛḻ-ɛɛs	‘one river’	bjaan-ɛɛ	‘the other’
c.	/n-saɛ-ɛɛ/	→ n-saɛ-ḻɛɛ	‘ascend it’	tumɛs-ɛɛ	‘squeeze it’
d.	/na-taɛ-ɛɛ/	→ na-taɛ-ḻɛɛ	‘answer it’		

The Amfo'an Meto data is discussed in more detail in next section (Section 5.5.1.4), where I also present arguments for the [l] being epenthetic, rather than underlying.

Other languages with liquid epenthesis include Anejom (Lynch 2000: 29), Baka (Kleinhenz 1992: 10, 12), Kɔnni (Lombardi 2002: 237), Japanese (de Chene 1985, Lombardi 2002: 236), Nigerian Pidgin (Faraclas 1996: 258), and Southern Tati (Yar-Shater 1969, de Lacy 2006: 81). These cases are considerably rarer than glide and glottal epenthesis, comprising 5.6% (2/36) of language-general patterns from the primary source survey. (In the literature meta-survey, they were substantially more common: 16/145, 11%, and so future work will need to confirm what proportion of these are language-general.)

5.5.1.3 Nasals

Although glides, glottals, and liquids make up a majority of language-general epenthetic consonants, there are other possible epenthetic consonant qualities as well. Epenthetic nasals, voiced stops, and voiced affricates are all attested, but are considerably rarer.

For an example, in Noon (Cangin; Soukka 1999) an epenthetic [n] is inserted to prevent vowel hiatus across morpheme boundaries.[48]

(344) Noon epenthesizes [n] to avoid hiatus at morpheme boundaries (Soukka 1999: 52)

	suffixed	gloss	bare
a. /oːmaː-iː/ child-DEF	oːmaː-niː	'the child'	oːmaː
b. /mati-o/ Mati-VOC	mati-no	'Mati!'	mati
c. /fu hot-in mati-e/ you see-PERF Mati-PQ	fu hotin mati-ne	'Have you seen Mati?'	mati
d. /fu an músú-aː/ you drink water-SUBJ	fu an músú-naː	'If you drink water'	músú

[48]Thanks to Juliet Stanton for bringing this case to my attention.

(345) None of the suffixes from (344) have an [n] after consonant-final words

	suffixed	gloss	bare	
a. /hal-iː/	hal-iː	'the door'	hal	'door'
b. /kilóok-óo/	kilóok-óo	'fiance-VOC'	kilóok	'fiance'
c. /fu jii lom-e/	fu jii lom-e	'2SG PROG buy-PQ'	lom	'buy'
d. /kuwis-aː, mi jii jah/	kuwis-aː. . .	'tomorrow-SUBJ'	kuwis	'tomorrow'

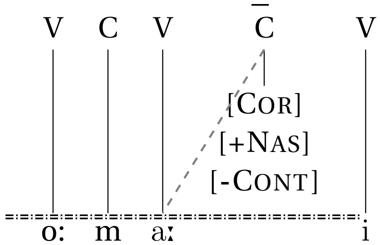
Note that the [n] cannot be analyzed as deletion, since Noon generally permits word-medial [Cn] clusters (e.g. [lom-neː] 'go and buy'; compare with [lom-e], 'buy-PQ' in (345c.), *[lom-ne]). For additional thorough arguments that this segment is epenthetic, see Stanton (in prep).

In Lamination Theory, Noon ranks DEP[NAS] low, along with DEP[-CONT], DEP[COR] and DEP[+CONS]. The coronal nasal is preferred over glides and onset [ŋ] due to markedness:

(346) Derivation of Noon /oːmaː-i/ → [oːmaːn-i] 'the child'

/oːmaː-i/	*V-V	*SPAWN-C	*j, w, *ONS[ŋ]	DEP[NAS]	DEP[COR]
a. oːmaː-i	*!				
b. oːmaːj-i		*	*!		
☞c. oːmaːn-i		*		*	*
d. oːmaːŋ-i		*	*!	*	

Candidate c. oːmːan-i



Coronal nasals (347a.) are preferred over liquids (347b.) and other stops (347c.-d.) due to other DEP[F] constraints. Glottal candidates (not shown below) are likewise ruled out by undominated DEP[C.G.]/DEP[S.G.].

(347) Nasals are preferred over other stops in Noon due to DEP[F] rankings

/oːmaː-i/	DEP[SON]	DEP[LAT]	DEP[LAB]	DEP[CONT]	DEP[NAS]	DEP[COR]
☞a. oːmaːn-i				*	*	*
b. oːmaːl-i		*!				*
c. oːmaːd-i	*!					*
d. oːmaːg-i	*!			*		
e. oːmaːm-i			*!	*	*	

The prediction this analysis makes for Noon is that glides and velar nasals must be highly marked (*GLIDE, *ONS[ŋ] in (346)). At least for velar nasals, this appears to be the case. In Noon, /ŋ/ is extraordinarily rare as a syllable onset, and occurs only in the word [ŋam] 'cheek' (Soukka 1999: 49-50). In all other cases, /ŋ/ only occurs as a coda.

Another prediction concerns the low ranking of DEP[NAS]. If DEP[NAS] is dominated (as it is in Noon), we might predict there to be other general nasalization patterns in the language. This prediction is borne out: Noon nasalizes obstruents in word-final position, as in (348).

(348) Voiced stops are nasalized in coda position (Soukka 1999: 49)

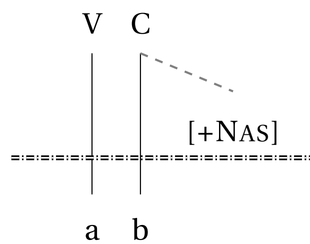
	underlying form		...C#	...C-in (-PERF)	...C-Riː (-NEG.PERF)
a.	/ab/	'hold'	[ʔam]	[ʔabin]	[ʔambiː]
b.	/sod/	'be tired'	[son]	[sodin]	[sondiː]
c.	/paj/	'marry'	[paɲ]	[pajin]	[paɲjiː]
d.	/lag/	'shut'	[laŋ]	[lagin]	[laɟgiː]

The alternations in (348) can also be understood as a consequence of DEP[NAS]. Codas are nasalized by epenthesizing [+NAS], as in (349):

(349)

ab	*OBSCODA	DEP[NAS]
a. ab	*!	
☞ b. am		*

Candidate b. [am] 'hold', cf. (348a.)



This analysis predicts that Noon should have two sets of nasals: those created through feature epenthesis, and those that are specified as nasals underlyingly.

For another example, Uradhi has epenthetic /ŋ/ (Australian, Crowley 1980, Paradis & Prunet 1993: 427). In utterance-final position, vowel-final words gain a velar nasal, as in (350). These contrast with words that are consonant-final, whose utterance-final forms undergo no change in (351).

(350) Uradhi (Atampaya dialect) inserts velar nasals in utterance-final position (Crowley 1980: 243-244)

	Utterance medial	Utterance-final	gloss
a. /ama/	ama	amaŋ	'person'
b. /juku/	juku	jukuŋ	'tree'
c. /iwi/	iwi	iwiŋ	'morning bird'
d. /luwu/	luwu	luwuŋ	'stonebird'

(351)

	Utterance medial	Utterance-final	gloss
a. /uðumpun/	uðumpun(a)	wapun	'back'
b. /wataj/	wataj(a)	wataj	'dugong'
c. /uŋkin/	uŋkin(a)	uŋkin	'flying fox'

There are other languages with nasal epenthesis as well, including Buginese (Mills 1975: 53), Kaingang (Yip 1992, de Lacy 2006: 81), Murut (Prentice 1971: 113), Sri Lanka Malay (Nordhoff 2009: 136), and Tunica (Haas 1940, Lombardi 2002: 234). Nasal epenthesis compose 8.3% (3/36) of the language-general patterns (13/145 in the metareview), but it's worth noting that much of the data on these languages is sparse. Noon is by far the clearest case of language-general nasal epenthesis. Lamination Theory predicts that these languages should indeed be rare, but perhaps more common than what has been observed so far.

5.5.1.4 Voiced obstruents

There are also languages that epenthesize voiced obstruents. Halh Mongolian (also known as Khalkha Mongolian) and Buryat are two famous examples of this, where epenthetic [g] appears to avoid vowel hiatus at morpheme boundaries (Poppe 1960, Sanzeev et al. 1962, Svantesseon et al. 2005, Staroverov 2014: 213).

In (352), I show the Halh Mongolian pattern, where [g/ɢ] is inserted to prevent hiatus at morpheme boundaries. By contrast, in consonant-final stems, no [g] is present. This occurs with a variety of suffixes, including the instrumental (352a.), genitive (352b.), precative (352c.), and reflexive (352d.). [49] Underspecified vowels (which alternate in vowel harmony) are written as capital letters.

(352) Halh Mongolian inserts [g/ɢ] to prevent hiatus at morpheme boundaries (Staroverov 2014: 213, data from Svantesson et al. 2005)

a.	/sana/	+ /Er/	→ sana-gar	'thought-INSTR'	cf. sana	'thought'
	/xiː/		→ xiː-ger	'air-INSTR'	xiː	'air'
	/xuː/		→ xuː-ger	'boy-INSTR'	xuː	'boy'
	/ai/		→ ai-gar	'category-INSTR'	ai	'category'
	/ɔi/		→ ɔi-gɔr	'forest-INSTR'	ɔi	'forest'
	/xui/		→ xui-gar	'group-INSTR'	xui	'group'
b.	/sana/	+ /iŋ/	→ sana-giŋ	'thought-GEN'	sana	'thought'
	/xuː/		→ xuː-giŋ	'boy-GEN'	xuː	'boy'
	/tepe/		→ tepe-giŋ	'swampland-GEN'	tepe	'swampland'
c.	/xaː/	+ /Etʃ^{h}/	→ xaː-ɢatʃ^{h}	'close-PREC'		
	/xuʒE/		→ xuʒe-getʃ^{h}	'wait-PREC'		
d.	/unE/	+ /E/	→ une-ge	'cow-RFL'		
	/nɔxt^{h}Ei/		→ nɔxt^{h}ɔi-gɔ	'dog-RFL'		
	/ɔr-t^{h}Ei/		→ ɔrt^{h}ɔi-gɔ	'place-COM-RFL'		

[49] Epenthesis also occurs in the prohibitive /-Utsai/ and prescriptive /-ErEi/ suffixes, not shown in (352).

(353) Consonant-final stems have no epenthesis

a.	/ar/	+ /Er/	→ ar-ar	'back-INSTR'	*ar-ɢar
b.	/ar/	+ /iŋ/	→ ar-iŋ	'back-GEN'	*ar-giŋ
c.	/og/	+ /Etʃ^{h}/	→ og-otʃ^{h}	'give-PREC'	*og-gotʃ^{h}
d.	/at/	+ /E/	→ at-a	'demon-RFL'	*at-ɢa

These cases have been disputed on the grounds that the conditioning environment is morphological. In both Halh Mongolian and Buryat, [g/ɢ] epenthesis is only found in derived environments, and could be readily reanalyzed as allomorphy (de Lacy 2006, de Lacy & Kingston 2013, Morley 2015). de Lacy and Kingston (2013) also observe that there are several strategies for hiatus resolution in Buryat, including vowel deletion, which they argue strengthens the case that [g/ɢ] insertion is morphohonologically conditioned. Staroverov (2014) argues that while this may be the case for Buryat, similar arguments do not apply to Halh Mongolian: [g/ɢ] epenthesis is real, and any typologically adequate theory of consonant epenthesis must be able to derive these qualities.

Fortunately, there are other languages that show clear epenthetic obstruents, and so less weight rides on the Buryat and Halh Mongolian cases.

In the Molo dialect of Uab Meto (a relative of Amarasi, Section 5.4.1), epenthetic /b, l, ɟ/ are conditioned by the place of the preceding vowel.[50] Round vowels conditions [b] (354a.), front mid vowels condition [l] (354b.), and high vowels condition [ɟ] (354c.).

[50] Data here comes from my own fieldwork in West Timor, Indonesia, and can also be found in Mooney (to appear).

(354) Molo consonant epenthesis of [b, l, ɟ] in CVV-V… contexts

a.	/ʔau-e/	→ [ʔauḇ-e]	‘the lime’	cf.	ʔau(b)	‘lime’
	/ʔao-e/	→ [ʔao-e]	‘the body’		ʔao(b)	‘body’
	/meo-e/	→ [meoḇ-e]	‘the cat’		meo(b)	‘cat’
b.	/fee-e/	→ [feeḻ-e]	‘the woman’		fee(l)	‘woman’
	/biɟae-e/	→ [biɟaeḻ-e]	‘the water buffalo’		biɟae(l)	‘water buffalo’
	/noe-e/	→ [noeḻ-e]	‘the river’		noe(l)	‘river’
c.	/ʔai-es/	→ [ʔaɟ̱-es]	‘a fire’		ʔai	‘fire’
	/hoi-e/	→ [hoɟ̱-e]	‘dry it’		hoi	‘dry’
	/fai-e/	→ [faɟ̱-e]	‘the night’		fai	‘night’

In CVCV words, the vowel completely hardens into a consonant, as in (355):

(355) Molo vowels harden into consonants [b, l, dʒ]

a.	/ʔasu-e/	→ [ʔasḇ-e]	‘the dog’	cf.	asu	‘dog
	/fatu-es/	→ [fatb-es]	‘a stone’		fatu	‘stone’
	/belo-e/	→ [belḇ-e]	‘the monkey’		belo	‘monkey’
b.	/ʔanoʔe-e/	→ [ʔanoʔḻ-e]	‘the lontar palm’		ʔanoʔe	‘lontar palm’
c.	/lolı-es/	→ [lolɟ̱-es]	‘a sweet potato’		lolı	‘sweet potato’
	/nafnafı-e/	→ [nafnafɟ̱-es]	‘the spider’		nafnafı	‘spider’
	/tasi-e/	→ [tasɟ̱-es]	‘the sea’		tasi	‘sea’
	/toti-e/	→ [totɟ̱-es]	‘ask it’		toti	‘ask’

There are two arguments for treating these segments as epenthetic, rather than underlying. First, plural allomorphy shows a distinction between consonant-final and vowel-final words. Consonant-final words take [-in]; vowel-final words take [-n] or [-nuk]. If the forms in (354) were underlyingly consonant-final, they should therefore take [-in] (e.g. /meob+PL/ → *[meob-in] ‘cats’). However, this is not the case: all of these words take suffixes for vowel-final words (e.g. /meo/ → [meo-nu] ‘cats’, /tasi/ → [tasi-n] ‘seas’). (See a similar argument for Amarasi in Section 5.4.1.)

The second argument is phonological. Words of a CVCVC shape undergo metathesis when they combine with a vowel-bearing suffix (Mooney to appear). For example, /kokɪs-e/ → [ko͡ɪks-e] 'the bread'. If the forms in (355) were consonant final, we would expect them to have the same behavior as the CVCVC words. We should see /fatub/ → *[fa͡ʊtb-e] 'the stone'. Again, this is not the case. Instead we see /fatu/ → [fatb-e] 'the stone', which suggests words like [fatu] 'stone' and [kokɪs] 'bread' differ in the presence of a final consonant.

In Lamination Theory, the Molo epenthesis pattern can be easily captured in terms of spreading. There are two crucial facts: first, that there are no surface glides allowed in the language (*GLIDE); and second, that feature insertion is only used as a last resort.

Epenthetic segments will thus inherit as many feature as they can from vowels, such as PLACE, while also inserting enough features to form non-glide consonants. Molo has six vowels /i, ɪ, e, a, o, ɔ, u/, and I minimally assume the high vowels all bear [DOR], the front vowels bear [COR], and the rounded vowels bear [LAB]. I define the constraints in (356)-(358), casting the constraint against glides as HAVEMANNER (cf. HAVEPLACE, Padgett 1995):

(356) HAVEMANNER: 'Consonants must have manner'
Assign a violation for a C-slot that is associated with no consonantal manner features (e.g. [±CONT, ±NAS, ±LAT]).

(357) DEP[F]: Assign a violation for a feature in the output that has no correspondent in the input.

(358) *SPAWN-C: Assign a violation for a feature that is associated with a C-slot in the output, but where the slot has no correspondent in the input.

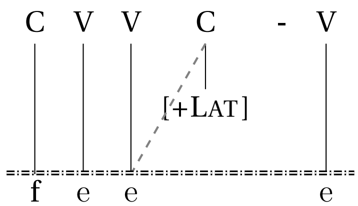
In the derivation of /fee-e/ → [feel-e] 'woman-DEF', the front mid vowel has [COR] place, which spreads onto the epenthetic C-slot. A lateral is inserted over a voiced obstruent because DEP[NAS] outranks DEP[LAT].

(359) Derivation of Molo /fee-e/ → [feel-e] ‘woman-DEF’

/fee-e/	*V-V	HAVEMANNER	DEP[PLACE]	DEP[NAS]	*SPAWN-C	DEP[LAT]
a. fee-e	*!					
b. feeʔ-e			*!			
c. feej-e		*!			*	
d. feeŋ-e				*!	*	
☞ c. feel-e					*	*

Representation of Candidate e. *feel-e

(360)



In other places of articulation that lack oral sonorants, like labials and dorsals, we see evidence that DEP[CONT] is dominated.[51] High front vowels condition [dʒ] and round vowels condition epenthetic [b], as in (361).

(361) Derivation of Molo /meo-e/ → [meob-e] ‘the cat’

/meo-e/	*V-V	HAVEMANNER	DEP[PLACE]	*SPAWN-C	DEP[LAT]	DEP[CONT]
a. meo-e	*!					
b. meow-e		*!		*		
c. meol-e			*!	*	*	
☞ d. meob-e				*		*

Even though DEP[LAT] is ranked low, it does not help us here — there are no labial or dorsal laterals.

The Molo ranking is HAVEMANNER, DEP[PLACE], DEP[NAS] ≫ DEP[CONT] ≫ DEP[LAT]. Epenthetic consonants will become the most sonorant consonant at a given place of articulation, excluding nasals.

[51] High vowels condition epenthetic [j], epenthesizing [-NAS, -CONT] features. The added wrinkle in this case is that multiple-linkage of high vowels is ruled out, and so the vowel fully hardens (e.g. /fai-e/ → [faj-e] ‘the night’, *[faij-e]).

To summarize, there are languages that have epenthetic voiced obstruents, ranging from dorsals (like [g/ɢ] in Halh Mongolian) to labials and coronals [b, ɟ] (as in Molo). We can therefore conclude that while voiced obstruents are rare between vowels (only 4/36 intervocalic; 9/36 in any context), they are possible.

5.5.1.5 Voiceless obstruents

Unlike voiced obstruents, voiceless obstruents never occur intervocalically in language-general epenthesis patterns. The patterns that do exist either (i) occur adjacent to another consonant, or (ii) bear morphological restrictions. (I discuss this in more detail in Section 5.6.)

To illustrate this first condition, consider consonant epenthesis in Ilocano (Rubino 1997). Ilocano inserts a homorganic stop between obstruent-sonorant clusters:

(362) Ilocano voiceless stops are inserted between obstruent and sonorant (Rubino 1997: 28)

a. /bisrad-en/ → bistrad-en 'spread open'

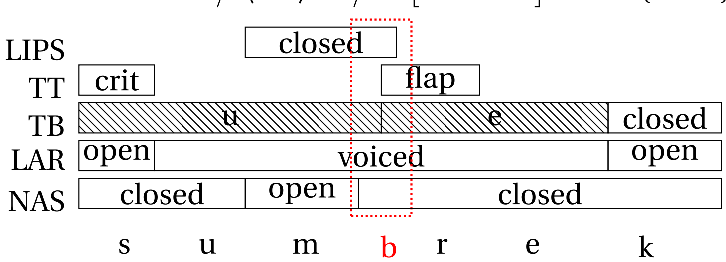
b. /serrek⟨um⟩/ → s⟨um⟩brek 'enter'

c. /pa-serrek-en/ → pa-strek-en 'allow to enter'

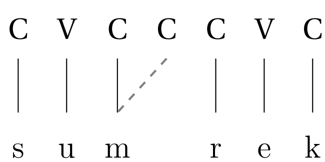
Lamination Theory derives the Ilocano case with spreading. Overlap between the nasal specification for oral obstruent and the sonorant cause a stop to form, as in (363):

(363) Gestural overlap in Ilocano responsible for epenthetic stops

a. Gestural score for /s⟨um⟩rek/ → [sumbrek] 'enter' (362a.)



b. Representation for [sumbrek]



In essence, these kinds of patterns receive the same treatment as intrusive stops, which I discuss in more detail in Section 5.6. The main difference between an intrusive and epenthetic stop is whether or not a C-slot is inserted, which will be determined by other phonological factors such as prosody.

Languages with this kind of pattern are not entirely rare — other examples include Urim (Papuan; Hemmilä & Luoma 2009: 12), Mato (Austronesian; Stober 2013: 21-22), and Old English (Indo-European; Hogg & Fulk 1992: 292), comprising 6/36 of the language-general patterns from the primary source survey. Notably, though, these epenthetic voiceless obstruents are always adjacent to a consonant or word edge.[52] In comparison, voiceless epenthetic obstruents are more common in morphologically-restricted patterns (9/29 languages), and may occur intervocalically.

To sum up, voiceless stops are possible as language-general epenthetic consonants, but they cannot occur intervocalically. The proposed typology of intervocalic, language-general epenthetic consonants is borne out: they are Loud and Proud, and tend to be as vowel-like as possible. Lamination Theory derives this by requiring language-general epenthetic consonants to spread from local sounds, and so intervocalic epenthesis will always involve spreading from a vowel.

5.5.2 Interim summary

In this section, I have argued that language-general epenthetic consonants are Loud and Proud. In intervocalic contexts, there is a strong tendency for them to be as vowel-like as possible. However, across different languages, restrictions on glides or on gestural lengthening can cause other strategies to come into play, allowing epenthetic nasals, liquids, and voiced obstruents to arise.

The picture that develops is one where there are few hard restrictions on what can and cannot be an epenthetic consonant. There is a cline in favor of more vowel-like consonants

[52] There were no counterexamples in the literature meta-review, either: voiceless epenthetic obstruents are never intervocalic and part of a language-general pattern.

in intervocalic contexts, but adjacent to other consonants or at word edges, this preference disappears.

In the next section, I reconsider evidence on voiceless epenthetic stops, such as /t/ epenthesis in Axininca Campa. I find that these patterns are not as robust as they have been claimed to be, and therefore are best analyzed as morphologically-restricted patterns that occur in the metamorph layer.

5.6 Generalization 3: Meek and discreet

In this section, I argue that while voiceless epenthetic consonants do exist, their distribution is highly restricted. Voiceless epenthetic consonants never appear between two vowels in a language-general pattern. When they do appear, they must occur next to other consonants or be conditioned by morphology.

The intuition here is that all language-general epenthetic consonants are assimilatory, and so voiceless obstruents will face a strong pressure to never occur between two segments specified for [+VOICE]. This generalization is therefore called *Meek and discreet*, reproduced in (364) below:

(364) **MEEK AND DISCREET**: Voiceless epenthetic consonants only appear (i) in non-intervocalic positions, or (ii) in morphologically-restricted patterns.

This section is structured into two parts. First, I give examples of truly general voiceless epenthetic obstruents, and apply Lamination Theory to predict their distribution in non-intervocalic positions. Second, I demonstrate that the typology of these morphologically-restricted patterns is quite broad, and quality may be phonologically arbitrary.

5.6.1 Voiceless obstruents at the margins

In the typological survey of language-general epenthesis, voiceless stops were only found at *margins*: They occurred adjacent to a consonant or a word boundary, but never between two vowels.

This observation is expected under Lamination Theory. Since epenthetic consonants are always mutations of existing gestures, they will only become voiceless (i) when they inherit voicelessness from the sound they originate from, (ii) other markedness constraints require it.

To illustrate, Mocho' inserts /x/ after all word-final vowels (Palosaari 2011: 111-112). All vowel-final words in Mocho' are Spanish loans — those that end in sibilants are adapted with word-final /ʃ/, those that end in sonorants surface faithfully.

(365) Mocho' loanword adaptation inserts word-final /x/ (Palosaari 2011: 111-112)

	Spanish loan	UR	surface form	gloss
a.	mesa	/mesa/	meʃax	'table'
b.	jarro	/xaro/	ʃaːrux	'jug'
c.	burro	/buro/	buːrux	'burro'

In Old English, nasal-liquid and strident-liquid sequences vary in the presence of a homorganic stop between the two consonants, shown in (366):

(366) Consonant epenthesis in Old English (Hogg 2011: 292)

	Variety A	Variety B	gloss
a.	*gandra*	*ganra*	'gander'
b.	*morgendlic*	*morgenlic*	'morning'
c.	*brambel*	*bremel*	'bramble'
d.	*symbel*	*symle*	'always'
e.	*ondrystlic*	*ondryslic*	'terrible'
f.	*æmptig*	*æmtig*	'empty'

Similar examples are attested in Modern English, where nasal-fricative sequences gain an excrescent stop (Gussenhoven and Broeders 1981, Clements 1987):

(367) Excrescent stops in Modern English (Gussenhoven and Broeders 1981: 108-109)

a. sʌmθɪŋ ∼ sʌmpθɪŋ ‘something’

b. sæmsən ∼ sæmpsən ‘Samson’

c. prɪns ∼ prɪnts ‘prince’

d. wɔrmθ ∼ wɔrmpθ ‘warmth’

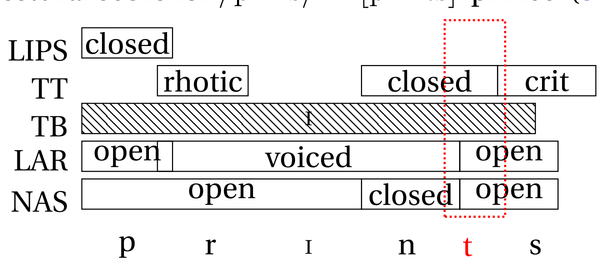
e. strɛŋθ ∼ strɛŋkθ ‘strength’

Previous work cast these kinds of stops in terms of gestural retiming (Barnitz 1974, Gick 1999), and have been termed “excrescent” or “intrusive” stops. Unlike other epenthetic consonants, these stops generally: (i) have much shorter duration than ordinary stops, (ii) disappear in careful, slow speech, and (iii) they appear to be a consequence of articulatory overlap, sharing place with their preceding consonant. Much of this literature has contended with the question of whether these cases constitute true epenthesis (e.g. Anderson 1976), or are a more “phonetic” coarticulatory effect (e.g. Barnitz 1974).

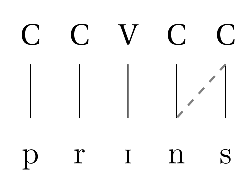
In Lamination Theory, these cases are exactly what we expect if we spread without inserting a timing slot. One consonant spreads onto the next, increasing the duration of their overlap. This produces an excrescent consonant:

(368)

a. Gestural score for /prɪns/ → [prɪnts] ‘prince’ (367c.)



b. Representation for [prɪnts]



What is the difference between an epenthetic consonant and an intrustive consonant? In Lamination Theory, the answer is simple: they differ only in the presence of a timing slot. Intrusive stops arise solely from spreading, but epenthetic stops require slot insertion and spreading.

What this predicts is that epenthetic consonants should be favored in phonology that cares about abstract timing slots, such as prosodic well-formedness constraints. We therefore might expect for epenthetic consonants to be more common when driven by constraints like ALIGNMENT (McCarthy and Prince, 1993b), the stress-to-weight principle (Gouskova, 2003; Prince, 1990) or CRISPEDGE (Itô and Mester, 1994, 1999). In comparison, intrusive stops do not build any additional structure; they only violate *SPAWN. Intrusive stops should therefore be absent from patterns that care about abstract structure-building — their presence should be explainable by other "flat" factors such as speech rate or coarticulatory markedness constraints.[53]

To summarize, language-general voiceless stops only appear to occur as intrusive stops — consonants that emerge from overlap of two different sets of gestures. Lamination Theory easily accounts for these in terms of spreading in the timing layer, capturing the intuition that these stops are surface-level timing effects. In comparison, epenthetic voiceless stops never arise intervocalically in language-general patterns (Meek and discreet). I claim that putative counterexamples — such as Axininca Campa epenthesis of /t/ (see Section 5.3.3.2) — all bear morphological restrictions.

5.6.2 Morphologically-restricted patterns

In morphologically-restricted patterns, epenthetic consonants are much less restricted in quality. As shown earlier in Figure 5.3, language-general epenthetic consonants vary greatly depending on whether they appear at margins or intervocalically. In comparison, morphologically-restricted patterns appear to have around equal rates of glides, glottals, nasals, stops, and fricatives.

For instance, /s/ is only attested as an epenthetic consonant in morphologically-restricted patterns. An example of this comes from Acehnese, which inserts epenthetic /s/ to fill out infixal templates when infixation is blocked.

In (369), I show how the nominalizing infix acquires an onset by linearizing after the first consonant of the stem.

[53] One such possibility is that in every language, as speech rate increases, the ranking of *SPAWN can be demoted. This would produce a cross-linguistic tendency for intrusive stops to arise at high speech rates.

(369) Acehnese polysyllabic stems bear nominalizing infix ⟨ɯn(ɯ)⟩ after first C (Asyik 1987: 54-55)

	root	nominalized form	gloss
a.	tarek	t<ɯn>arek	‘thing that’s pulled’
b.	padʒoh	p<ɯn>adʒoh	‘food’
c.	balot	b<ɯn>alot	‘thing for wrapping’
d.	salen	s<ɯn>alen	‘the copy’
e.	pɯ-duek	p<ɯn>ɯ-duek	‘arrangement’

When the stem begins with a liquid or labial, infixation is blocked. In these cases, epenthetic /s/ is used to fulfill the onset requirement of the infix template:

(370) Monosyllabic stems with initial labial or liquid do not infix; /s/ inserted instead (Asyik 1987: 62)

	root	nominalized form	gloss
a.	p^{h}ɯet	s̲<ɯnɯ>p^{h}ɯet	‘carving’
b.	mɯeŋ	s̲<ɯnɯ>mɯeŋ	‘lap’
c.	wʌ̃t	s̲<ɯnɯ>wʌ̃t	‘thing which is mixed’
d.	lhat	s̲<ɯnɯ>lhat	‘hook’
e.	rheŋ	s̲<ɯnɯ>rheŋ	‘thing which is spun’

Epenthetic /s/ is limited to this one context in Acehnese. Elsewhere in the language, the epenthetic consonant is a glottal stop, which prevents vowel hiatus within stems (e.g. /sɯuəm/ → [sɯʔuəm] ‘hot’, Asyik 1987: 20).

If morphophonological epenthesis here operated in the same layer as the language-general pattern, we would expect a single ranking to be responsible for /s/ insertion and glottal stop insertion, which would ostensibly favor one quality across the board. Instead, what we find is that morphophonological epenthesis is not only calculated separately, but can bear qualities never attested in language-general patterns.

Epenthetic consonants in morphologically-restricted patterns can also be non-minimal, inserting entire syllables at a time. An example of this comes from Wangkajunga, a Western

Desert (Pama-Nyungan) language spoken in Australia (Jones 2010). Wangkajunga inserts an epenthetic syllable *pa* to certain consonant-final words. It optionally appears on loanwords (371a.) and native words ending in consonants (371b.). It appears obligatorily on consonant-final words between the stem and pronominal clitics (371c.).

(371) Wangkajunga epenthetic syllable *-pa* (Jones 2010: 38-39)

a.	*seed(pa)*	'seed'	
	lizard(pa)	'lizard'	
	hunting(pa)	'hunting'	
	gooseberry(pa)	'gooseberry'	
	roadboardcamp(pa)	'roadboard camp'	
b.	*nganjarr(pa)*	'outside'	
	kilyirr(pa)	'coals'	
	wartil(pa)	'hunting'	
	jiin(pa)	'this'	
	jarrawan(pa)	'bush onion'	
	ya-nin(pa)	'go.PRS'	
c.	*marrany-pa=ya*	'dingo-EP=3PL.NOM'	**marrany=ya*
	ya-nin-pa=pula	'go-PRS-EP=3DU.NOM'	**ya-nin=pula*
	yu-ngun-pa=jananya	'go-PST-EP=3PL.ACC'	**yu-ngun=jananya*
	ngayu-n-pa=laju	'1-PL-EP=1PL.EXCL.NOM'	**ngayu-n=laju*

This pattern is morphologically restricted.[54] In order to know the distribution of obligatory *pa*, we must know which morphemes are pronominal clitics. Clitics must be preceded by *pa* when their host word is consonant-final, as in (371c.). Yet, the clitics cannot bear *pa* themselves, as in (372), even though this can create surface consonant-final words:

[54] Diachronically, this epenthesis pattern may have had origins as some kind of clitic that indicates clause type or focus (cf. modal auxiliary in Walmatjarri, McConvell 1996: 305; Pintupi, Hansen & Hansen 1978:216)). Synchronically, however, it appears to be semantically bleached, and it is widely analyzed as an epenthetic syllable in most Western Desert languages (Hale 1973, Jones 2010).

(372) Wangkajunga pronominal clitics cannot bear *pa* themselves (Jones 2010: 39)

a. *wiya=n* 'NEG=2SG.NOM' **wiyan=n-pa*

b. *wanja-ngurru=n* 'where-ABL=2SG.NOM' **wanja-ngurru=n-pa*

c. *ya-nku=n* 'go-FUT=2SG.NOM' **ya-nku=n-pa*

Similar non-minimal epenthesis patterns are also attested in other languages, such as Chintang (*-na*, Bickel et al. 2007: 50). Like Wangkajunga, this syllabic epenthesis is morphologically restricted, and only applies to verbal stems. I predict that these cases of syllabic epenthesis should only occur in metamorph layer, since timing layer epenthesis is always minimal.

5.7 Generalization 4: Invisible Man

In this section, I turn to the Invisible Man generalization. The Invisible Man generalization states that language-general epenthesis is never visible to certain kinds of phonology, including stress assignment, allomorph selection, and reduplication. This is stated in (373):

(373) **Invisible man:** Language-general epenthesis is never visible to certain kinds of phonology: weight-sensitive stress assignemnt, allomorph selection, reduplication, or word minimality.

At least where allomorphy is concerned, the Invisible Man generalization is intuitive, and is assumed as an implicit diagnostic in many contemporary treatments of epenthesis (e.g. Staroverov 2016: 482). One common way to evaluate whether a segment is epenthetic or underlying is to see whether it can condition allomorphy. If the allomorph appears to be conditioned by the presence of the segment, it is underlying; otherwise it is epenthetic.

However, in many contemporary models, there is nothing that requires this diagnostic to work in this way. If we interleave Spellout with rounds of phonological application, as in Cophonology Theory (Inkelas and Zoll, 2007), then there is no reason to assume that allomorph selection can never be conditioned by epenthesis. Stress assignment at least appears to operate either way: it can be conditioned by epenthesis, or it can be blind to it (Elfner, 2009). It should therefore be surprising that epenthesis and allomorphy can only work in one direction.

In my model, Invisible Man follows from how language-general phonology and morphophonology operate over different representational layers. Allomorphy can only see the underlying segmental and metrical layers, but not the surface timing layer that language-general phonology manipulates. The Invisible Man generalization thus follows from the broader idea that morphophonology and language-general phonology are representationally distinct.

In my survey, the Invisible Man was found to be exceptionless for allomorph selection. No language-general epenthesis pattern is visible to phonologically-conditioned suppletive allomorphy. For example, Haitian Kreyol epenthesizes a glide in tense-lax vowel hiatus sequences (374a.), but not in lax-lax ones (374b.).

(374) Haitian Kreyol epenthesizes a glide in tense-lax vowel sequences (Valdman 1978: 75, via Klein 2003: 2)

a.	/ru-a/	→ [ruwa]	'the wheel'
	/po-a/	→ [powa]	'the skin'
	/diri-a/	→ [dirija]	'the rice'
	/pje-a/	→ [pjeja]	'the foot'
b.	/papa-a/	→ [papa]	'the father'
	/bɔkɔ-a/	→ [bɔkɔa]	'the sorcerer'
	/vɛ-a/	→ [vɛa]	'the glass'

Additionally, the definite suffix has two allomorphs, [-a] after vowel-final roots, [-la] after consonant-final roots (Klein, 2003). This is shown in (375).

(375) Haitian Kreyol definite suffix has two phonologically-conditioned allomorphs (Klein,

2003)

	Consonant-final words select *-la*				Vowel-final words select *-a*		
a.	/malad/	[malad-la]	'the sick (person)'	f.	/papa/	[papa-a]	'the father'
b.	/ʃat/	[ʃat-la]	'the cat'	g.	/bujwa/	[bujwa-a]	'the kettle'
c.	/liv/	[liv-la]	'the book'	h.	/papje/	[papje-ja]	'the paper'
d.	/bagaj/	[bagaj-la]	'the thing'	i.	/lapli/	[lapli-ja]	'the rain'
e.	/kaw/	[kaw-la]	'the crow'	j.	/bato/	[bato-wa]	'the boat'

Crucially, Haitian Kreyol consonant epenthesis is invisible to allomorph selection. If consonant epenthesis were visible to allomorph selection, we would expect to see forms like *[ruw-la] 'the wheel'. Instead, we see these forms take [-a] in (375h.-j.).

For another example, in Washo glottal stops are epenthesized to vowel-initial words (376a.) vs. (376b.). But, with the second-person possessive prefix, we see that this epenthesis is again invisible. Underlyingly vowel-initial stems take the [m-] allomorph (376c.), consonant-initial stems take the the [ʔum-] allomorph (376d.).

(376) Glottal stop epenthesis does not feed allomorph selection in Washo (Staroverov 2016: 482)

a.	/aŋal/	→ ʔaŋal	'house'	c.	m-aŋal	'your house'
	/emlu/	→ ʔemlu	'food'		m-emlu	'your food'
b.	/ʃuː/	→ ʃuː	'chest'	d.	ʔum-ʃuː	'your chest'
	/ʔaːt'u/	→ ʔaːt'u	'older brother'		ʔum-ʔaːt'u	'your older brother'

In Kisar (Christensen and Christensen, 1992), we see the same pattern. Vowel-initial words gain an epenthetic glottal stop, as in (377):

(377) Kisar epenthesizes a glottal stop to vowel-initial words

a.	/eni/	→ [ʔeni]	'this'
b.	/omhe/	→ [ʔamkuru]	'sleep'
c.	/elek/	→ [ʔesne]	'kill'
d.	/omun/	→ [ʔomun]	'drink'

But Kisar glottal epenthesis is invisible to reduplication (378), and it is invisible to 1SG allomorph selection (379).

(378) Kisar epenthesis is invisible to reduplication

/eni/	→ [ʔeni]	'this'	
/RED-eni/	→ [ʔeni-eni]	'this one here'	*[ʔeni-ʔeni], *[eni-ʔeni]

(379) Kisar 1SG allomorph selection (#C jaʔu vs. #V jV) not fed by epenthesis

Consonant-initial words take jaʔu

a.	/jaʔu hiʔi/	→ [jaʔu hiʔi]	'I do'
	/jaʔu karu/	→ [jaʔu karu]	'I bury'
	/jaʔu ʔomhe/	→ [jaʔu ʔomhe]	'I wash'
	/jaʔu ʔelek/	→ [jaʔu ʔelek]	'I close'

Vowel-initial words take jV

b.	/jV amkuru/	→ [ja ʔamkuru]	'I sleep'
	/jV esne/	→ [je ʔesne]	'I kill'
	/jV omun/	→ [jo ʔomun]	'I drink'

Invisible Man is significant because not all phonology is invisible to allomorph selection. Reduplication, for instance, is visible to phonologically-conditioned suppletive allomorphy.

An example of a visible reduplication-epenthesis interaction is seen in Yindjibarndi (Stanton, 2022; Wordick et al., 1982). Stanton (2022) analyzes the Yindjibardi locative as having two phonologically-conditioned allomorphs for common nouns: /-ŋga/ after consonant-final words that are disyllabic or smaller, and /-la/ elsewhere. In (380), I illustrate the base pattern with vowel-final words:[55]

(380) Yindjibarndi locative allomorphy is conditioned by stem size (Stanton, 2022; Wordick

[55] Consonant-final words also condition changes in the realization of initial consonants /ŋg/ and /l/, see Stanton (2022) for details.

et al., 1982)

a. Disyllabic stems take /-ŋga/

malu-ŋga	'shade-LOC'
ŋura-ŋga	'ground-LOC'
t̪ama-ŋga	'fire-LOC'

b. Larger stems take /-la/

paɹkara-la	'plain-LOC'
kupica-la-ŋu	'small-LOC-ABL'
piʈat̪a-la	'dry.leaf-LOC'

Notably, reduplication is visible to allomorph selection in Yindjibarndi. Although the bare stem in (381) takes [-ŋga] (because it is disyllabic), the reduplicated stem takes [-la], showing that the copied string is counted when measuring stem size.

(381) Yindjibarndi reduplication is visible to allomorph selection (Wordick et al. 1982: 132)

a. Bare stem selects -ŋga

waru-ŋga-mu	'tomorrow'	(stem is two syllables)
night-LOC-ANA		

b. Reduplicated stem selects -la

waru-waru-la-mu	'first light'	(stem is four syllables)
night-RED-LOC-ANA		

Language-general consonant epenthesis thus has a weaker relationship to allomorph selection than reduplication. Epenthetic segments are never visible to allomorphy, but reduplication can be. From this, we can conclude (i) that reduplication and allomorph selection have access to the same representations, and (ii) that information-sharing between the metamorph and phonetic timing layer is highly asymmetric: while morphophonology can is visible to language-general phonology, the opposite is not true.

5.8 Alternatives

In this chapter, I have focused on the typology of consonant epenthesis, attempting to give an analysis that uses abstract phonological representations but preserves gestural intuitions. The core intuition is that epenthetic consonants are not inserted from nothing — rather, they are transformations of existing gestures. I now briefly discuss two alternatives, Staroverov (2014)'s Splitting Theory (5.8.1) and Steriade (2009)'s P-Map theory. I then conclude.

5.8.1 Alternative 1: Splitting Theory

Staroverov (2014) argues that epenthetic consonants are always assimilatory. His theory ("Splitting Theory") asserts that epenthetic consonants always split from adjacent vowels, violating INTEGRITY. An input vowel splits into two correspondents, one of which surfaces as a faithful vowel, another of which surfaces as an unfaithful consonant. The shared intuition here with Lamination Theory should be clear: epenthetic consonants always emerge from transforming neighboring sounds.

Staroverov (2014)'s original theory proposes two generalizations in the typology of consonant epenthesis. First, Splitting Theory predicts that epenthetic PLACE should always match with adjacent vowels, which analytically follows from its lack of a feature insertion mechanism. Both my survey and Staroverov (2016) found this to be false: there are patterns where PLACE must be epenthesized, such as Noon (Section 5.5.1.3) and Washo (Section 5.5.1.1). The second gap Staroverov (2014) predicts is that spreading should be impossible from consonants. As already discussed in Section 5.6, this is too restrictive. Obstruent epenthesis almost always involves spreading from consonants, which is responsible for the greater range of qualities in consonant-adjacent positions (*Meek and discreet*).

These two issues are dealt with easily enough and do not bear on the broader conceptual difference between Splitting Theory and Lamination Theory: that of representation. Splitting Theory uses segments, but Lamination Theory uses slot-and-feature representations.

While this may appear to just be a difference in notation, the choice of representation has significant consequences for how these theories define locality restrictions. Any theory of assimilatory consonant epenthesis must rule out non-local epenthetic interactions. The patterns that are important to rule out are those where a non-local segment conditions epenthetic quality. A hypothetical example could be a language that inserts [w] when there is any round vowel preceding it in the word, but inserts a [j] otherwise (e.g. /tuta-i/ → [tu_1taw_1-i], but /teta-i/ → [te_1taj_1-i]). These kinds of cases are unattested, and so locality restrictions are adopted to rule them out.

The problem, then, is defining exactly what "local" means. Lamination Theory, for instance, uses slot-and-feature representations, and so locality is defined by what can spread over what (Section 2.2.1). This ends up equating to what kinds of gestures can fully overlap. In comparison, Splitting Theory defines its locality restriction segmentally. This is never fully formalized in Staroverov (2014) — he simply states that "splitting is local… for an input /$\alpha_1\beta_2$/ splitting cannot yield [$\gamma_1\delta_2\epsilon_1$] where the correspondents of /α/ surround the correspondent of /β/ (Staroverov 2014: 16)". I offer one way of restating this in (382) below:

(382) SEGMENTAL LOCALITY: When two output segments correspond with the same input, they must be adjacent. (cf. Staroverov 2014: 16, 46)

I now introduce an empirical problem for Staroverov's segmental locality, but not the spreading-based version of locality in Lamination Theory.

Let's return to Amarasi non-structure preserving /g/ epenthesis from Section 5.4. In Amarasi, there is a metathesis pattern that makes consonant epenthesis opaque. The conditioning vowel (the final vowel of the root) is not segmentally adjacent to the epenthetic consonant on the surface.[56]

(383) Surface non-locality in Amarasi epenthetic consonants

a.	/fatu-es/	→ [fautg̲-es]	'a stone'	[fatu]	'stone'
b.	/ʔasu̲-e/	→ [ʔausg̲-e]	'the dog'	[ʔasu]	'dog'
c.	/kero̲-e/	→ [keorg̲-e]	'the monkey'	[kero]	'monkey'
d.	/mepo̲-e/	→ [meopg̲-e]	'work it'	[ʔa-mepo-t]	'worker'
e.	/nafnafɪ̲-e/	→ [nafnaɪfg̲-e]	'the spider'	[nafnafɪ]	'spider'

[56] Cross-dialectal evidence from Miomafo supports the conclusion that the root vowel conditions /g/, not the suffix vowel. In Miomafo, the epenthetic stop transparently matches the quality of the final root vowel: [fautb-e] 'the stone', [taisɟ-e] 'the sea' (Nona Seko, p.c.).

f.	/tasi̲-e/	→ [taɪsg̲-e]	'the sea'	[tasi]	'sea'
g.	/toti̲-e/	→ [toɪtg̲-e]	'tell it'	[toti]	'ask'

In Splitting Theory, this kind of case violates SEGMENTAL LOCALITY. An epenthetic consonant corresponds to a non-adjacent vowel.

One way to fix this would be to relax the locality condition, for instance by allowing correspondence in adjacent syllables. Staroverov (2014) entertains this for vowel copy epenthesis (p. 206), but again does not formalize it fully. I offer one such implementation here:

(384) SEGMENTAL LOCALITY (revised): When a two output segments correspond to a single input vowel, they must surface in adjacent syllables. Two output segments that correspond to an input consonant must be linearly adjacent.

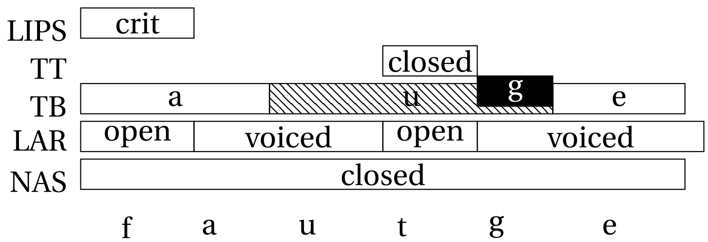
Note that this locality restriction is asymmetric, as it only allows syllable-adjacent correspondence for segments that correspond to a vowel in the input. This asymmetry is necessary because otherwise consonant gemination could produce non-local copies, another unattested pattern (cf. Kawahara 2007, see Chapter 4).

While this revised locality condition is compatible with the Amarasi data, it doesn't explain the situation very well. Why are the locality conditions on consonant and vowel segments different? Why can vowels split into consonants in neighboring syllables, but not farther?

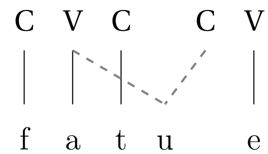
Evaluating the same data with gestural representations is more illuminating. The Amarasi data can be analyzed in terms of spreading (see detailed analysis for Meto in Chapter 3), where the vowel gesture spreads leftwards. Crucially, the segment remains anchored in its original position. This is schematized in (385:

(385) Amarasi epenthetic /g/ spreads from local /u/ (made opaque by metathesis)

a. Gestural score for /fatu-e/ → [fautge] 'the stone' (383a.)



b. Representation for [fautge]



Under my analysis, there is nothing non-local about Amarasi epenthesis at all. Amarasi allows vowels to spread across consonants, giving the impression that the vowel conditioning the epenthetic consonant has moved, but in reality the features remain in situ. These kinds of patterns are therefore reliant on consonant-vowel line crossing being possible — we should only see this kind of pattern in languages with (vowel) copy-epenthesis, vowel harmony, or metathesis. (So far, this prediction is (vacuously) satisfied. Amarasi does this, and Amarasi has metathesis.)

Splitting Theory and Lamination Theory thus reach a similar state: to correctly derive attested epenthesis patterns, Splitting Theory must adopt locality restrictions consistent with gestural locality. This raises the question of if segments are the best representational choice for modeling consonant epenthesis, since it is gestures, and not segments, that are referenced by the phonological machinery.

5.8.2 Alternative 2: Steriade (2001/2009)'s P-Map

Steriade (2001) proposes that constraint rankings reference a separate component of grammar — the P-Map. The hypothesis is that speakers tend to preserve contrasts that are more perceptible. The P-Map contains a hierarchy of perceptibility contrasts (along with contexts); ranked faithfulness constraints then must preserve this hierarchy.

The result is that ordinary faithfulness constraints like IDENT, MAX and DEP are derived from the P-Map hierarchies to create highly context-dependent faithfulness rankings. As an example, consonant deletion is easier to perceive before a vowel than between two consonants: the P-Map produces the constraint ranking MAXC/V_C ≫ MAXC/V_V.

It is worth noting that this system, while adequate for accounting for the range of data, is extremely powerful. There is little the theory cannot derive, and so any restrictions on the typology, if they exist, must be explained in terms of independently-motivated differences in perception.

For consonant epenthesis, a P-Map analysis could predict many of the same things as Lamination Theory. Glides, for instance, are not expected to be highly perceptible between vowels, and so violations to DEP should be easier in this scenario. Similarly, consonants that are homorganic in place with a neighboring vowel may also be less perceptible, and this reasoning could capture the assimilatory tendency of language-general patterns.

The core conceptual question at stake is whether perception or articulation is responsible for these facts. The P-Map would contend it is all perception. In Lamination Theory, it could be articulation, or it could be a mix of both. While spreading is about coarticulatory ease, DEP[F] rankings are more fluid. The ranking of DEP[F] could be compatible with a P-Map approach.

The question between these two frameworks, then, is an empirical matter, which needs to be resolved in future work. If a P-Map analysis is on the right track, then languages where epenthetic PLACE does *not* match nearby sounds (/j/ in Washo, /n/ in Noon) should be motivated strictly by perceptibility. This is testable; we expect speakers of these languages to fare worse in perception tasks for these epenthetic segments than speakers of phonetically comparable languages.

5.9 Conclusion

In this chapter, I argued that the typology of consonant epenthesis is not uniform. When we consider language-general and morphologically-restricted patterns side by side, we find that there are differences.

On the whole, language-general epenthesis appears to occupy a more restricted typology. For instance, voiceless obstruents can never occur between two vowels (*Meek and discreet* generalization). Sonorants tend to fill these intervocalic positions, leading to a distribution of epenthetic consonant qualities that is highly context-dependent. In comparison, morphologically-restricted patterns seem much less restricted: voiceless obstruents, for example, can occur in any position.

I also demonstrate that language-general epenthetic consonants are almost always assimilatory in some way. They may inherit features of nearby vowels or nearby consonants. The intuition is thus that epenthetic consonants tend to minimally perturb the original gestural dynamics by transforming existing ones.

To capture these data, I propose that language-general consonant epenthesis is derived through spreading, a way of representing gestural lengthening. From there, features may be inserted individually to improve markedness violations, prodding the gesture into a new form. The picture that emerges is that epenthetic consonants are mutations of existing sounds: they lengthen what they can, and insert what they must.

Chapter 6

Conclusion

In this thesis, I introduced a problem I called the Reordering Asymmetry. When phonological patterns appear to reorder sounds, such as in metathesis and copy epenthesis, they tend to bear morphological restrictions. To describe where and when the alternations take place, it is necessary to make reference to morpheme identity, not just phonological boundaries or sound.

By exploring typologies of metathesis and copy epenthesis further, I find that the Reordering Asymmetry goes deeper — it concerns more than where these patterns apply, but also what characteristics they have when they do. While morphologically-restricted patterns appear to reorder segments fully (according to phonetic and phonological diagnostics), the language-general ones do not. Language-general reordering patterns always bear the hallmarks of gestural overlap in the sense of Hall (2003): they are phonetically incomplete and they are phonologically invisible, so that their phonological behavior is consistent with their original order rather than their surface one. I call this property of language-general patterns Order Preservation, because these patterns always bear indisputable cues to the precedence relations in their input.

Based on these asymmetries, I therefore claim that the Reordering Asymmetry is much stronger than a mere bias in favor of morphological restriction: it is a ban on complete segmental reordering in language-general patterns. I argue that phonology must be bifurcated into two components of grammar: a morphologically-restricted component that can reorder sounds, and a language-general one that cannot.

While the claim that phonology is bifurcated into two kinds of grammar is an old one, it is nonetheless contentious in contempoary phonology. Most contemporary phonology adopts what I call the Phonological Uniformity hypothesis — the idea that phonology is a single, computationally uniform component of grammar. Phonological Uniformity has been the standard since Chomsky and Halle (1968), and has since percolated out into all varieties of Optimality Theory (parallel: Prince and Smolensky 1993, stratal: Bermúdez-Otero 1999, 2003; Kiparsky 2000 cophonologies: Anttila 2002; Inkelas and Zoll 2007; Orgun 1996). The core idea is that phonological alternations may differ in where they apply, but in practice any pattern can be morphologically-restricted or language-general.

I argue that Phonological Uniformity is incorrect. Based on both the Reordering Asymmetry and Order Preservation, it is clear that there are asymmetries between language-general and morphologically-restricted reordering patterns. These patterns must differ not only in where they occur, but also in their fundamental character.

The thesis is therefore organized around building a constraint-based model of grammar that assumes a bifurcated phonology, which I call Lamination Theory. Lamination Theory proposes that there are multiple layers of phonological representations, each of which can interact with phonological GEN in different ways. In the timing layer, phonological alternations can be conditioned by sound alone, but phonological GEN must "work with what it's got". It can lengthen, shorten, or slightly mutate existing gestures so that they are easier to pronounce, but it cannot rewrite, delete, or reorder features fully. In comparison, the metamorph layer has a far more powerful GEN, closely resembling the unrestricted GEN assumed in classic Parallel OT. Features in the metamorph layer can be rewritten and reordered fully, but alternations must be driven by higher-level requirements relating to prosody or the specific needs of individual morphemes.

In Chapter 3, I apply Lamination Theory to the typology of metathesis. I argue that metathesis is split into two major kinds of patterns: language-general metathesis and morphologically-restricted metathesis. I demonstrate that language-general metathesis is consistent with gestural nesting and overlap (following Hall 2003). It is phonetically incomplete, and it is phonologically invisible with respect to stress, other phonology like consonant deletion, and allomorph selection. In comparison, morphologically-restricted metathesis does appear to reorder sounds on a deeper abstract level, where metathesis can affect other phonology, even where language-general metathesis cannot. I therefore argue that metamorph GEN can transpose and reorder features, but timing GEN cannot. Timing GEN can only spread, keeping features locked in their original positions.

Chapter 4 focuses on copy epenthesis, again focusing on the differences between language-general and morphologically restricted patterns. When copy epenthesis patterns are general, they invariably bear segmental restrictions, only allowing copying across certain kinds of consonants (usually sonorants). Just as in metathesis, language-general copy epenthesis patterns are phonologically invisible, and do not affect stress assignment, allomorphy, or reduplication. By contrast, morphologically-restricted copy epenthesis is both phonologically visible and often segmentally blind, meaning that it can occur with no restrictions on the copying vowel or intervening consonant. Based on this typology, I argue that language-general copy epenthesis must arise through spreading (following Kawahara 2007), not long-distance correspondence. Copy epenthesis that uses long-distance correspondence to copy segments must be restricted to the metamorph layer of phonological grammar, along with reduplication.

Chapter 5 then turns to consonant epenthesis. While not based in reordering, the typology of consonant epenthesis also shows a split in its typology between language-general and morphologically-restricted patterns. I observe that language-general consonant epenthesis patterns are always at least assimilatory — they may inherit place, manner, or voicing from surrounding sounds, but never differ in all three. By contrast, morphologically-restricted consonant epenthesis does not have the same assimilatory bias, and can insert epenthetic segments that are extremely different from surrounding sounds, such as voiceless obstruents in intervocalic contexts. I argue that this typology follows from how timing and metamorph GEN differ on their ability to insert new sounds. While metamorph GEN can epenthesize new segments from nothing, timing GEN can only spawn segments by spreading from neighboring sounds.

Lamination Theory has broader applications beyond the split typologies found in metathesis, consonant epenthesis, and copy epenthesis. If phonology is bifurcated into two components, then we expect to see parallel splits in the typologies of other phonology. Similar kinds of splits have already been observed in stress-epenthesis interactions (Broselow, 1982; Elfner, 2009; Hall, 2006), nasalization (Cohn, 1990), palatalization in English (Zsiga, 2000), and vowel devoicing in Japanese (Tsuchida, 1997, 1998). Further splits are expected in local harmony, assimilation, and dissimilation, whereas stronger asymmetries (more along the lines of what we saw with metathesis) are expected for non-local forms of these same patterns.

Beyond these typological predictions, Lamination Theory's layered representations can also be seen as a way of unifying the phonetics-phonology interface. A persistent question has been how to derive phonetic gradience or phonological invisibility without abandoning abstract, atomic representations (see Cohn 1993 for review).

In this, Lamination Theory has an answer: phonetic gradience and phonological invisibility arise from asymmetries in how information can percolate through the different representational layers. When the specifications in different layers conflict, the phonetics must split the difference, blending together the information from both layers to form a gradient output. Phonological invisibility follows from how information can travel from the metamorph layer up to the timing layer, but not back down. The result is a representation that has distinct components for the formation of each layer, but where the layers must be fused into a complex, information-dense output that does not perfectly resemble any single layer of its input.

Appendix A

Appendix

A.1 Mono copy epenthesis

Here I sketch out a formalized analysis of two kinds of copy epenthesis in Mono (Hall, 2003; Olson, 2003). We can formalize the liquid cluster epenthesis in terms of four constraints, defined in (386)-(389) below. All four of these are timing layer constraints.

(386) *COMPLEX: Assign a violation for a C-slot that is not immediately followed by a V-slot.

(387) *LNCROSS[LIQ,VOWEL]: Assign a violation for each pair of association lines that cross that are both [+SON,-NAS].

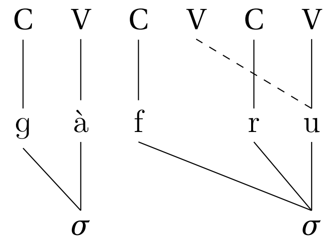
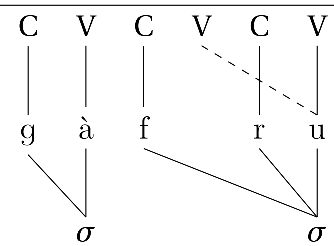
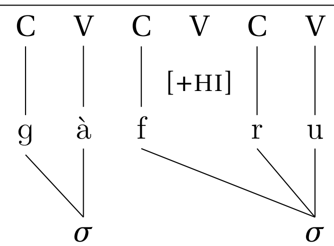
(388) *SPAWN[VOWEL]-V: Assign a violation for a [+SYLL] segment that is associated with more than one slot.

(389) DEP[HI]: Assign a violation for [HIGH] features in the timing layer.

Other related constraints are undominated, such as *FLOAT, *LNCROSS[NAS], *LNCROSS[STR], *LNCROSS[OBS], and so on. Since vowels and liquids are the most specified, they are easiest to spread across other sounds.

Inputs like /gàfrū/ are realized as gàf<u>ū</u>rū 'mortar' (390b.), avoiding the *COMPLEX violation (candidate a.) without violating DEP[HI] (candidate b.).

(390)

/gàfrū/	*COMPLEX	DEP[HI]	*SPAWN-V	*CROSS[LIQ,V]
a.  gàfrū	*!			
☞ b.  gàfū̲rū			*	*
c.  gàfirū		*!		

The word minimality epenthesis, by comparison, is a metamorph layer effect. I define three constraints in (391)-(393) below.

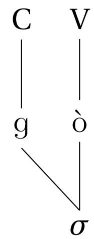
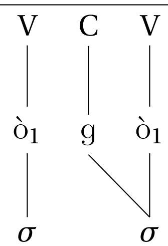
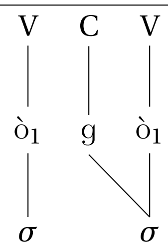
(391) MINBINARITY: ‘A root has a minimum of two syllables’ (Ito and Mester, 2007)

(392) DEP: Assign a violation for each segment in the output that has no correspondent in the input.

(393) HE-IDENT[F]: Assign one violation mark for each pair of vowels standing in HE correspondence that do not have identical values for [F]. (Stanton and Zukoff 2018: 640)

In roots like /gò/ ‘hunger’, word minimality epenthesis is driven by MINBIN. A full segment inserts, and it must be identical to the root vowel by HE-IDENT. (I assume that vowelless syllables are ruled out by a markedness constraint against minor syllables.)

(394)

/gò/	MINBIN	HE-IDENT	DEP
a.  gò	*!		
b.  ògò			*
c.  $\grave{\imath}_1 g \grave{o}_1$		*!	*

The invisibility of word minimality epenthesis follows from how metamorph layer constraints are defined (the Blindness Condition, Section 2.5.1). Metamorph constraints can only reference morphemes, segments and deeper prosodic structure. As such, they cannot be improved by by changing slots or association lines. The two sets of constraints thus fail to freely interact, making the liquid cluster epenthesis invisible to the word minimality one.

A.2 Consonant epenthesis: Literature meta-review

This review compiled 146 patterns from the following sources: Beavon (1991), Blevins (2008); Culhane (2018); de Lacy (2006); De Lacy and Kingston (2013); Inkelas (2014); Ito and Mester (2009); Lombardi (2002); McCarthy and Prince (1994); Morley (2015); Ortmann (1998); Rubach (2000); Staroverov (2014); Uffmann (2007); Vaux (2002); Żygis (2010).

The reported typology, shown in (395), appears quite broad, with very few gaps. Some notable ones include /tʃ/ and /f/, but otherwise it appears that most natural classes of consonants can be epenthetic.

(395) Reported epenthetic consonant qualities from the literature (146 patterns, 34 families)

	Labial	(Post-)Alveolar	Palatal	Velar	Uvular	Glottal
Plosive	p b	t d	ɟ	k g		ʔ
Nasal	m	n		ŋ		
Liquid		r ɹ l				
Affricate		dʒ				
Fricative	v	s ʃ ʒ		x ɣ	ʁ	h
Approximant	w ʋ		j			

I claim that this typology is not an accurate representation of what is possible in language-general epenthesis patterns. Many of the patterns in (395) are morphologically restricted, which I argue do not share the same restrictions as language-general patterns.

Additional details are summarized in Table A.1, including the language name, family, and segment types. When two sources provide different accounts of what the epenthetic segments are, the segments from each account are separated by a semicolon.

Family	Language	Segments	Source
Afro-Asiatic	Berber	ʔ; j	Staroverov 2014: 213, Morley 2015: 46
Algic	Odawa	t	Lombardi 2002: 242
	Plains Cree	t	Morley 2015: 17

Family	Language	Segments	Source
	Ritwan	h	Blevins 2008: 7
	Yurok	h	Blevins 2008: 7
Arawakan	Axininca Campa	t	McCarthy & Prince 1994
	Chamicuro	j, w	de Lacy 2006: 81
Atlantic-Congo	Badwe'e	w	Beavon 1991: 67
	Baka	l	Ortmann 1998: 72
	Gokana	r, n	Lombardi 2002: 235
	Kɔnni	r, ʔ	Lombardi 2002: 237
	Nzime	b	Beavon 1991: 67
	Wolof	j, w, ʔ, k	Morley 2015: 41
	Yoruba	r	Ortmann 1998: 72
Austroasiatic	Nancowry	ʔ	Morley 2015: 38
Austronesian	Acehnese	h	Blevins 2008: 8
	Aklanon	h	Blevins 2008: 7
	Anejom	ɹ	de Lacy 2006: 81
	Balangao	w, j	Morley 2015: 44
	Buginese	ŋ	Vaux 2001: 15
	Hawaiian	ʔ, h, k, l, m	Staroverov 2014: 215, Morley 2015: 42
	Ilocano	j, w, ʔ	Lombardi 2002: 227
	Indonesian	ʔ	Lombardi 2002: 228
	Kalinga	j, w, ʔ	de Lacy 2006: 79
	Karo Batak	j, w, ʔ	Staroverov 2014: 215
	Kisar	ʔ	Lombardi 2002: 228
	Land Dayak	s, x	Vaux 2001: 16
	Larike	ʔ	de Lacy 2006: 80
	Mabalay Atayal	ʔ	Morley 2015: 38
	Madurese	ʔ	de Lacy 2006: 82
	Makassarese	j, w, ʔ	Staroverov 2014: 216
	Malay	ʔ	Inkelas (2014: 252)
	Maori	t k	de Lacy 2006: 80
	Meto (Amarasi)	g^{w}, g	Culhane 2018
	Meto (Amfo'an)	g^{w}, l, b, dʒ	Culhane 2018
	Motu	l	Vaux 2001: 16
	Muna	ʔ	Blevins 2008: 7
	Murut	n	de Lacy 2006: 81
	Rennellese	ʔ	Blevins 2008: 7
	Selayarese	ʔ	Lombardi 2002: 226
	Tagalog	ʔ	Inkelas (2014: 176)
	Trukese	k	Staroverov 2014: 217
	Woleaian	j, w	Staroverov 2014: 218
Bantu	Shona	j, w	Uffman 2007: 458
Chadic	Chadic	ʔ	de Lacy 2006: 80

Family	Language	Segments	Source
	Hausa	j, w, ʔ	Morley 2015: 44
Chukutko-Kamchatkan	Koryak	ʔ	Lombardi 2002: 228
Dravidian	Abujhmaria	j, w, t	Morley 2015: 42
	Brahui	ɣ	de Lacy 2006: 79
	Koḍava	j, v, k	Staroverov 2014: 215
	Koya	j, v	Staroverov 2014: 216
	Malayalam	j, v	Morley 2015: 44
	Tamil	j, w, ʔ	Lombardi 2002: 225, Culhane 2018: 26-27
Eskimo-Aleut	Inuktitut	ŋ	Vaux 2001: 15
	Kalaallisut	ʔ, j, ʝ, w, v	Staroverov 2014: 215
	Yupik	ʁ	Blevins 2008: 8
Hokan	Karok	ʔ	Inkelas (2014: 27)
Indo-European	Armenian (Southeast)	j	Morley 2015: 46
	Bulgarian	ʔ	Rubach 2000: 287
	Greek (Cretan and Mani)	ʒ	Vaux 2001: 16
	Czech	j, ʔ	Rubach 2000: 298
	Danish	k	Morley 2015: 41
	Dutch	j, w, ʔ; n; s	de Lacy 2006: 79, Ortmann 1998: 65, Zygis 2010: 116
	East Frankonian	n	Zygis 2010: 118
	English (Boston)	ɹ	de Lacy 2006: 81
	English (Bristol)	ɫ	Lombardi 2002: 231
	Faroese	j, w, ʋ	Staroverov 2014: 214
	French	t	de Lacy 2006: 80
	German	ʔ; t	Lombardi 2002: 226; Zygis 2010: 116
	Greek	n	Vaux 2001: 15
	Icelandic	s	Zygis 2010: 117
	Middle Frankish	ʀ	Ito & Mester 2009: 184
	Northern Bavarian	r	Zygis 2010: 117
	Polish	j, w; l	Rubach 2000: 291; Vaux 2001: 16
	Sanskrit	n	Vaux 2001: 15
	Spanish (Sevillian)	r	Vaux 2001: 15
	Spanish (Dominican)	s	Staroverov 2014: 217
	Swiss German (High Alemannic)	n	Ortmann 1998: 59
	Swedish	s	Zygis 2010: 116
	Ukrainian	j	Staroverov 2014: 217
(Indo-Iranian)	Farsi	j, w, ʔ	Staroverov 2014: 215

Family	Language	Segments	Source
	Marathi	v	Vaux 2001: 16
	Pishaca	j	Vaux 2001: 16
	Sinhala	j, w	Morley 2015: 42
	Southern Tati	r, j, w	de Lacy 2006: 81
Iroquoian	Mohawk	ʔ	de Lacy 2006: 80
	Onondaga	ʔ, h	Lombardi 2002: 229
(isolate)	Basque (Lekeitio/Deba, Zumaia)	ʃ	Vaux 2001: 16
	Basque (Markina, Urdiain, Etxarri, Lizarraga)	b	Vaux 2001: 16
	Basque (Zaraitzu)	r	Vaux 2001: 15
	Seri	k	Kingston & de Lacy 2013
	Tunica	n, ʔ	Lombardi 2002: 234
	Washo	j, ʔ	Staroverov 2014: 218
Japonic	Japanese	r; j, w	Lombardi 2002: 236; Uffman 2007: 458
	Korean	t, n	Staroverov 2014: 215
Macro-Je	Kaingáng	ŋ	de Lacy 2006: 81
Mayan	Yucatec Maya	ʔ, h	Lombardi 2002: 229
Mongolic	Buriat	g, ɣ	Staroverov 2014: 213
	Mongolian	g, ɣ	Staroverov 2014: 216
Oto-Manguean	Ayutla Mixtec	h	de Lacy 2006: 80
Pama-Nyungan	Alyawarra	w, j	Morley 2015: 44
	Nhanda	ʔ, h, j, w	Blevins 2008: 7
	Uradhi	ŋ	de Lacy 2006: 81
Panoan	Huariapano	h	Lombardi 2002: 229
Peba-Yaguan	Yagua	h	de Lacy 2006: 80
Quechuan	Cuzco Quechua	ʔ, h	Staroverov 2014: 214
Semitic	Amharic	t	Lombardi 2002: 241
	Arabic (unspecified)	ʔ; j	Lombardi 2002: 225; Vaux 2001: 16
	Arabic (Cairene)	j, w, h	Morley 2015: 44
	Argobba	j, w	Morley 2015: 44
	Tigre	h	de Lacy 2006: 80
Sino-Tibetan	Ao (Chungli)	j, w	Staroverov 2014: 213
	Bisu	ʔ	Zygis 2010: 128
	Cantonese	j, w, ʔ, ŋ	Staroverov 2014: 213
	Chintang	ʔ	Blevins 2008: 7
	Manipuri	j, w	Staroverov 2014: 216
	Maru	t, k	Vaux 2001: 15
Siouan	Dakota	j, w	de Lacy 2006: 79
Tangkic	Lardil	t, k	Kingston & de Lacy 2013
Totonac-Tepehua	Misantla Totonac	ʔ	de Lacy 2006: 80

Family	Language	Segments	Source
Tucanoan	Tucanoan	h	de Lacy 2006: 80
Turkic	Uyghur	j	de Lacy 2006: 81
Uralic	Finnish	t	Vaux 2001: 15
Uto-Aztecan	Cupeño	ʔ	Lombardi 2002: 229
	Tubatulabal	ʔ	Morley 2015: 38
Wakashan	Nuu-Chah-Nulth (Tsishaath Nootka)	ʔ	de Lacy 2006: 80
Yeniseian	Carrier	j, w, h	Staroverov 2014: 213
	Chipewyan	h	de Lacy 2006: 80
	Slave (Hare and Bearlake)	h	de Lacy 2006: 78

Table A.1: Literature meta-review. Epenthetic qualities across different languages.

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