PHONOLOGY OF VOWEL DEVOICING: A TYPOLOGICAL PERSPECTIVE

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PHONOLOGY OF VOWEL DEVOICING: A TYPOLOGICAL PERSPECTIVE

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This dissertation presents a systematic phonological analysis and typology of vowel devoicing based on a large-scale cross-linguistic survey of 70 processes from 53 languages. While previous literature on the phenomenon has primarily focused on its phonetic properties and mechanisms, I argue that vowel devoicing's interaction with other phonological processes in a number of the languages in which it occurs necessitates an account of its phonological mechanisms as well.

I propose a typological model of vowel devoicing that focuses on the distinct roles of prosodic structure and segmental phonology in conditioning its application, which I treat as two separate, but potentially interacting parameters. This yields three categories of vowel devoicing. When the prosodic parameter operates alone, it yields processes sensitive only to prosodic structure. Specifically, processes in this category are restricted to certain prosodically weak positions. When the segmental parameter operates alone, it yields processes sensitive only to the local segmental environment. The processes in this category are restricted to vowels adjacent to particular voiceless and/or aspirated consonants. Finally, the interaction of the two parameters yields processes sensitive to both prosodic structure and segmental phonology. The processes in this final category are restricted to vowels in specific weak positions that are also adjacent to specific types of consonants. Crucially, since all three scenarios are well-attested cross-linguistically, I argue that a complete phonological analysis of vowel devoicing cannot reduce the phenomenon to a single mechanism, but rather, must include separate prosodic and segmental mechanisms.

I then propose a formal, constraint-based analysis of vowel devoicing that attributes the two distinct mechanisms to two different types of markedness constraints. While this analysis is general enough to account for all processes in the relevant typological categories, I also illustrate its language-specific applications with case studies from diverse families and geographic regions, including Cheyenne (Algonquian, North America), Comanche (Uto-Aztecan, North America), Niuafo'ou (Malayo-Polynesian, Tonga), and Wallaga Oromo (Cushitic, Ethiopia).

Finally, I demonstrate that when vowel devoicing is considered from a phonological perspective, it yields crucial implications for larger issues in phonological theory. These include the nature of laryngeal features in Feature Theory, the distinct roles of prosodically strong and weak positions in segmental phonology, and the nature and role of domain generalization in the distribution of phonological processes within a given language.

BIOGRAPHICAL SKETCH

Rachel Vogel was born in Philadelphia, PA in 1993. She received her BA from Swarthmore College in 2016, where she studied Linguistics and Peace and Conflict Studies. She then worked at the Smithsonian Institution's Recovering Voices Initiative before beginning her graduate studies in Linguistics at Cornell University. At Cornell, she received her MA in Linguistics in 2020 and is graduating with her PhD in 2022.

This dissertation is dedicated to my mother and Forrest.

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Additionally, although we have not directly worked together for several years, I will always be deeply grateful for the ongoing and incredibly generous support and mentorship from Gabriela Pérez Báez, starting when I interned for her at the Smithsonian Institution after my sophomore year of college. She inspired me to pursue linguistics as an undergraduate student and later to continue my studies in graduate school. She also taught me to believe in and constantly seek out the intersections between my academic pursuits and my social and political values.

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CHAPTER 1

INTRODUCTION

Laryngeal properties including voicelessness and voicing have long been observed to exhibit fundamentally different patterns in obstruents and sonorants. The divergent patterns are generally attributed to different phonetic sources and different phonological statuses of the laryngeal properties in the different types of segments (e.g., early discussions in Chomsky & Halle 1968; Halle & Stevens 1971). While in obstruents, voicelessness is widely considered to be unmarked and is often represented phonologically with the absence of a laryngeal specification, in sonorants, including vowels, it is voicing that is taken to be the unmarked or default case (see further discussion in Section 1.2 of this dissertation). When voicelessness appears in sonorants, therefore, it must be represented with the specification of a laryngeal feature rather than the absence of such a specification. In vowels in particular, not only is voicelessness marked with respect to voicing, but it is also never contrastive (Gordon & Ladefoged 2001; Ladefoged & Maddieson 1990). Voiceless vowels do, however, appear on the surface in diverse languages around the world. In such cases, they are in complementary distribution with voiced vowels, arising as a result of phonetic or phonological processes of vowel devoicing. This dissertation presents a systematic phonological analysis and typology of vowel devoicing (abbreviated VD), based on a large-scale cross-linguistic survey of 70 processes from 53 languages.

Within the field of phonology, vowel devoicing is a relatively understudied phenomenon, and indeed has often been considered rare or marginal (Gordon 1998; Gordon & Ladefoged 2001; Tsuchida 2001). Even though two cross-linguistic studies, including Greenberg's work in the 1960s, have shown vowel devoicing processes to be considerably more common than generally assumed (Gordon 1998;

Greenberg 1969), the marginal status of VD has persisted, and few instances of VD were examined in detail beyond the well-known case of High Vowel Devoicing in Japanese (e.g., Han 1962; McCawley 1968) until relatively recently.

In the 1990s, vowel devoicing began to attract more attention and become a subject of interest in a growing variety of languages. Although these more recent studies of VD offer welcome advancements to our understanding of the phenomenon, as will be discussed further in Chapter 2, the majority of this additional work – both in Japanese and in other languages – has focused on its phonetic properties, including its acoustic and articulatory realizations, and its underlying phonetic mechanisms. In fact, some literature has made explicit arguments to the effect that VD should be considered a fundamentally phonetic, rather than phonological, process. That is, it arises just as the result of undershoot or overlap between glottal gestures associated with a (voiced) vowel and an adjacent voiceless consonant, rather than as a phonological phenomenon involving a change in feature values. This can be seen, for example, in previous works such as Jun & Beckman 1993, 1994 (focusing on Korean and Japanese, along with with references to several other languages) and Jannedy 1995 (focusing on Turkish).

As I will demonstrate in the next section, however, examination of vowel devoicing within the context of a language's full phonological system reveals, in a number of cases, crucial interactions with other phonological processes. These interactions indicate that the vowels in question must devoice within the phonological component of their languages rather than as a matter of phonetic implementation, thus necessitating specifically phonological accounts of VD, in addition to the phonetic ones. This dissertation addresses the dearth in phonological research on vowel devoicing, drawing on evidence from a large and diverse set of languages. In fact, I will show not only that the phonological properties and mechanisms of VD are meritorious of investigation themselves, but also that they offer the opportunity to examine and address a number of broader issues in phonological theory. These include the nature of laryngeal features in Feature Theory, the relationship between prosodic prominence and segmental phonology, and the roles of phonologization and domain generalization in the distribution of phonological phenomena within a given language.

While the analysis developed in this dissertation is based on large-scale cross-linguistic patterns, subsequent chapters illustrate language-specific applications of the major generalizations with more detailed discussions of a number of individual languages from diverse linguistic families and geographic regions. These include Cheyenne (Algonquian, North America), Comanche (Uto-Aztecan, North America), Niuafo'ou (Malayo-Polynesian, Tonga), and Wallaga Oromo (Cushitic, Ethiopia). It is also demonstrated how the approach that I develop not only accounts for the specific phenomena included in this dissertation but also offers insights and predictions about the nature of vowel devoicing more broadly.

In the rest of this chapter, I first present the motivation for a phonological approach to vowel devoicing in Section 1.1. Then, because it will be seen throughout this dissertation that vowel devoicing interacts closely both with laryngeal properties of adjacent segments and with prosodic structure, I introduce theoretical concepts and assumptions that are fundamental to the discussion of each of these topics. Specifically, in Section 1.2, I discuss laryngeal features associated with voicelessness and voicing in vowels as well as in other types of segments. Then, in Section 1.3, I discuss aspects of prosodic structure that are relevant for VD, focusing on prominence relations within prosodic structure and their interactions with segmental phonology. Finally, I outline the contributions of this dissertation and the structure of the subsequent chapters in Section 1.4.

1.1 Motivation for phonological approaches to vowel devoicing

As noted above, the majority of research on vowel devoicing has focused primarily on its phonetic properties and mechanisms. Nevertheless, in a number of languages in which vowel devoicing is found, it interacts with other elements of the phonological system in complex ways that indicate that it must take place within the phonology. Particularly relevant are opaque interactions between vowel devoicing and other phonological processes. For instance, VD processes in Cheyenne (Algonquian, Leman & Rhodes 1978) and Comanche (Uto-Aztecan, Robinson & Armagost 2012) are in counter-bleeding relationships with other phonological processes. That is, the conditioning environments of vowel devoicing in these languages are eliminated in some (or all) surface forms by the application of another phonological process.

Detailed case studies of these vowel devoicing processes will be presented in Chapters 3 and 4 of this dissertation, however, it suffices here to note certain general patterns. In the case of Cheyenne, the VD process in question devoices vowels in word-final syllables when they are followed by voiceless consonants. Another process, however, epenthesizes an [e] after word-final obstruents and thus consistently obscures the prosodic conditioning environment of the devoicing process on the surface. In Comanche, vowels devoice before /s/ and /h/, regardless of whether the vowel and consonant are in the same syllable. [h] subsequently deletes in coda positions, however, causing the segmental conditioning environment of certain instances of VD to be obscured on the surface. Illustrations of the Comanche patterns are seen in (1)-(3) below.

In (1), Comanche vowel devoicing applies before intervocalic /s/ and /h/, while in (2), vowels are seen not to devoice before other types of consonants including stops and nasals. Voicelessness is marked with the IPA diacrtitic (e.g., i̥). Here, and in the rest of this section, the relevant vowels in each example are shown in bold font.

(1) Comanche VD before /s/ and /h/ (Robinson & Armagost 2012)

a. [kup**i̥**simawa] ‘croton weed’

b. [wanaʔ**ɯ̥**hu] ‘cloth blanket’

(2) No Comanche VD before stops or nasals (Robinson & Armagost 2012)

a. [suʔ**a**tsitɯ] ‘think about something, make a plan’

b. [pasap**u**ni] ‘cross-eyed person’[1]

Crucially, when vowels devoice before an /h/ that is subsequently deleted, they may appear before other types of consonants on the surface. This is shown in (3), where devoiced vowels are observed in surface environments resembling those in (2).

(3) Comanche VD where coda [h] is deleted (Robinson & Armagost 2012).

a. [miʔ**ḁ**tsi] ‘having gone’ (from underlying /miʔ**a**htsi/)

b. [habik**ɯ̥**ni] ‘bedroom’ (from underlying /habik**a**hni/)

[1] Stress was not marked in the original source for this example, but it is likely that the first syllable is stressed, explaining why the [a] in that position does not devoice before [s]. The role of stress is vowel devoicing is discussed later in this dissertation.

Such a pattern cannot result from gestural overlap with an adjacent [s] or [h] during phonetic implementation, because the triggering consonants are no longer present after the other phonological operations have been completed.

Another type of interaction requiring a phonological analysis of vowel devoicing can be seen in cases where VD feeds another phonological process. For example, in Comanche, an independent process raises certain low vowels that have been devoiced to mid vowels but does not affect voiced low vowels (Robinson & Armagost 2012). In other cases, VD feeds stress and accent assignment, as seen in a number of languages, including Awadhi (Indo-Aryan, see Gordon 1998), Miami-Illinois (Algonquian, see Costa 2003), and Tunica (isolate, see Gordon 1998).

In sum, the existence of interactions between vowel devoicing and other phonological phenomena observed in a variety of languages indicates that VD must take place within the phonological system. That is, vowel devoicing must be interspersed with other phonological processes in those languages, and consequently cannot always be reduced to phonetic effects of gestural undershoot or gestural overlap.[2] The phonological nature of at least some VD processes makes it imperative for a complete understanding of the phenomenon that we address more than just its phonetic mechanisms. Specifically, a systematic investigation of the phonological mechanisms of vowel devoicing, in addition to, and independently from, its phonetic mechanisms is required, and thus constitutes the basis for this dissertation. It will be seen, furthermore, that the present investigation and analysis of the phonological mechanisms of VD not only inform our understanding of the specific phenomenon,

[2]Note that this dissertation does not make explicit predictions or assumptions about the relationship between gradience vs. categoricity and phonetics vs. phonology. While it is often assumed that phonological processes are categorical and phonetic processes are gradient, it is clear that the situation is more complex (e.g., Cohn 2006, 2007; Ernestus 2011), and that post-lexical phonology may be particularly subject to gradience (e.g., Ernestus 2011 and references therein). I therefore focus on evidence from phonological interactions rather than descriptions of categorical or gradient realizations.

but also provide critical implications for, and insights into, several broader issues in phonological theory.

1.2 Laryngeal features

As noted at the beginning of this chapter, voicelessness is considered to be marked in vowels with respect to voicing. Moreover, as will be discussed further in Chapter 2, voiceless vowels are never contrastive (Gordon & Ladefoged 2001; Ladefoged & Maddieson 1990). Rather, they arise only as a consequence of phonological or phonetic processes of vowel devoicing. Because voicing and voicelessness are in general associated with different states of the glottis, and because voicelessness is marked in vowels, I assume that vowel devoicing involves either a change in specification or an addition of a laryngeal feature. This is in contrast to common approaches to obstruent devoicing which, as discussed later in the section, can be attributed to delinking of a laryngeal node. In order to understand the phonological aspects of vowel devoicing and their implications for larger issues in phonological theory, it is therefore essential to consider how the laryngeal representations of voiceless vowels relate to those of other types of segments. As will be seen in subsequent chapters, this dissertation argues that two distinct laryngeal representations of voiceless vowels are needed to account for the full cross-linguistic range of segmental environments involved in VD: [-voice] and [+spread glottis]. Since the vowel devoicing processes under consideration often depend on features spreading from adjacent voiceless or aspirated consonants, the analysis ultimately has crucial implications for consonants as well as for vowels.

This section provides the background on laryngeal features necessary to contextualize the proposal made later in this dissertation. First, I provide an overview of the relatively few discussions of laryngeal features in previous studies of vowel devoicing. Then, to situate this dissertation's proposal in a broader context, I introduce some basic considerations concerning more general issues for laryngeal representations in Feature Theory, as discussed in prior literature. In particular, I focus on the question of whether laryngeal features are binary or privative. It will be seen that the majority of the previous broad claims about laryngeal features are motivated primarily by obstruent phonology. Sonorant consonants are also incorporated into some of the proposals, but to a lesser degree. By contrast, the implications for, or from, the laryngeal properties of vowels have for the most part remained unexplored. The phonological perspective on vowel devoicing developed in this dissertation brings the remaining category of segments into focus, and thus provides a novel, yet fundamental, contribution to the issue of laryngeal features in phonological theory.

1.2.1 Phonological approaches to laryngeal representations of devoiced vowels

As discussed earlier in this chapter, there has been relatively little phonological research on vowel devoicing, and even fewer studies have explicitly addressed the phonological laryngeal representations of devoiced vowels. Instead, the focus tends to be on the articulatory mechanisms and the articulatory and acoustic manifestations of vowel devoicing. (See Chapter 2 of this dissertation for an overview of these studies.) Across the studies that do discuss the laryngeal representations of VD, two different feature specifications have been introduced, [-voice] and [spread glottis], both of which are generally associated with a relatively open glottis. Typically, the assumption in this work has been that only one of the features is necessary to account for vowel devoicing; it is simply a question of which one. However, there has been little systematic consideration of which feature should be used or why one should be preferred over the other.[3]

Earlier featural accounts of the well-known case of Japanese High Vowel Devoicing (e.g., McCawley 1968) attributed voicelessness in the vowels to the feature [-voice]. In more recent analyses of Japanese and several other languages, however, it has been argued that voicelessness in vowels is associated with a [spread glottis] feature instead (Cho 1993; Tsuchida 1997, 2001). The [spread glottis] feature has also been used in some other recent phonological research on voiceless vowels, without explicit discussion or motivation of the choice (e.g., Louie 2010 on Northern Paiute).

The arguments for using [spread glottis] over [-voice] in phonological analyses of VD have been based on several types of evidence. These, in turn, reflect different assumptions about both the nature of phonological features and the relationship between these features and phonetics. In her analysis of Comanche and Acoma, Cho (1993) bases the choice of [spread glottis] entirely on the phonological facts of these particular languages. Specifically, she argues that the natural class of consonants that triggers VD in the languages in question (i.e. fricatives /s/ and /h/, but not other voiceless consonants) is best characterized by [spread glottis], and that vowel devoicing results from the spreading of this feature to an adjacent vowel.

[3]There is also a body of research approaching vowel devoicing from an Articulatory Phonology perspective, which does not consider featural representations. Rather, this work attributes vowel devoicing to gestural overlap between glottal gestures associated with (voiced) vowels and adjacent voiceless consonants (e.g., Chitoran & Babaliyeva 2007; Delforge 2008; Jannedy 1995; Jun & Beckman 1993, 1994). The interactions between VD and other phonological phenomena discussed in 1.1, however, require a categorical change in representation incompatible with gestural overlap accounts. I therefore focus here on investigations that involve featural analyses of VD processes.

In Japanese on the other hand, for which investigation of the laryngeal representations of voiceless vowels has been more extensive, the arguments for [spread glottis] have been based on a mix of phonological and articulatory phonetic considerations. For an example, Tsuchida (1997) observes that the glottis is especially wide during the production of voiceless vowels in Japanese (i.e. wider than during voiceless stops), and thus argues that this type of articulation is better described using [spread glottis] than [-voice]. (See Tsuchida 1997 and references therein.) This approach to Japanese laryngeal representations crucially assumes a particular model of direct mapping between articulatory glottal states and laryngeal features. It is unclear, however, to what extent this constitutes a conclusive argument, and whether it might pertain to languages beyond Japanese, since the nature of the mapping between phonological features and phonetic realizations remains an open and debated question in phonology. (See, for example, Honeybone 2005 and Schwarz, Sonderegger, & Goad 2019 for discussions of the different views regarding the relationship between laryngeal features and phonetics.) While the use of [spread glottis] may be the correct choice for Japanese phonologically, further analysis and a more thorough understanding of the relationship between phonetic properties and phonological features remains outstanding.

The approach taken in this dissertation distinguishes itself from phonetically-oriented approaches to featural representations in that it is based entirely on phonological evidence. Crucially, rests on the natural classes of segments involved in vowel devoicing cross-linguistically.

1.2.2 The nature of laryngeal representations in Feature Theory: binary vs. privative

Although this dissertation is concerned with laryngeal representations of voiceless vowels, it may additionally be viewed within the broader discussion of the nature of laryngeal features in Feature Theory. While it has been noted as far back as Chomsky & Halle 1968 and Halle & Stevens 1971 that laryngeal properties in general, and voicing in particular, have different statuses in obstruents and sonorants, the majority of broader claims about laryngeal features are motivated primarily by obstruent phonology. Two important issues in this literature concern a) the particular set or sets of features needed, and b) the question of whether these features are binary or privative. While the two issues are related, I focus here on the latter, since is the issue to which the findings of this dissertation are most relevant.

The earlier literature on phonological features, including laryngeal features, assumed that they were all binary, with "+" and "-" values specified in the phonological representation and targeted by phonological rules or processes (e.g., Chomsky & Halle 1968; Halle & Stevens 1971). Starting around the 1990s, however, an influential body of literature developed arguments for privative laryngeal features, allowing only one value for each feature to be specified (e.g., Brown 2016; Cho 1990; Lombardi 1991, 1995; Mester & Itô 1989). In the rest of this subsection, I first outline a major phonological argument advanced in favor of privative laryngeal features. I then present a recent counterargument favoring binary laryngeal features instead, in particular, focused on binary [voice]. I also highlight the implications of this debate for the phonological analysis of vowel devoicing.

Privative [voice]

A major argument for privative laryngeal features can be found in Lombardi 1995. Lombardi observes that across languages with diverse systems of laryngeal contrasts, positional laryngeal neuralization in obstruents consistently produces the same outcome: voiceless, unaspirated, and unglottalized segments. She argues that these patterns require an analysis whereby neutralization arises from the delinking of a laryngeal node with privative features, as shown in Figure 1.1.

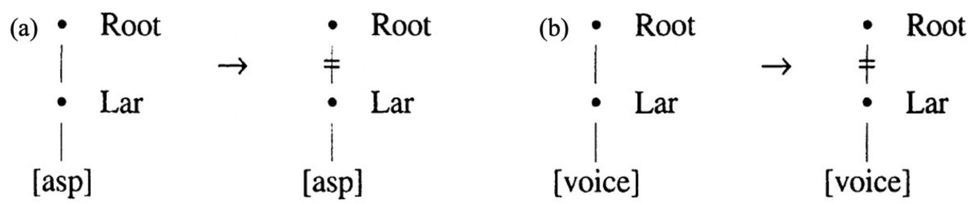

Figure 1.1: Laryngeal neutralization as delinking of Lar node. (a) = neutralization of [asp] feature; (b) = neutralization of [voice] feature (from Lombardi 1995, p. 39)

This delinking analysis accounts for the observation that neutralization always proceeds in the same direction (toward plain, voiceless obstruents), since the absence of laryngeal specifications can only produce the unmarked, default property. If neutralization were instead represented as a change from one binary feature value to another (e.g., [+voice] → [-voice] or [+asp] → [-asp]), we would incorrectly predict that neutralization in the other direction should be possible as well (e.g., [-voice] → [+voice] or [-asp] → [+asp]).

While this argument is based on obstruent phonology, Lombardi also addresses sonorants, for which she notes that voicing is the unspecified default, requiring a somewhat different approach. Specifically, she cites cross-linguistic phonological patterns showing that i) voicing is predictable for sonorants, and ii) the [voice] feature is not active in phonological processes for sonorants in the same way it is for obstruents. Voicelessness in sonorants therefore cannot result from the absence of laryngeal specifications the way it can for obstruents. In order to account for the existence of voiceless sonorants without resorting to [-voice], Lombardi invokes the proposal of Mester and Itô (1989), according to which the property that appears to be voicelessness in sonorants is instead due to aspiration (represented by an [asp] or [spread glottis] feature). It should be noted that while the proposals in both Lombardi 1995 and Mester & Itô 1989 diverge from earlier work in arguing for a privative rather than binary system, the view that "voiceless" sonorants are actually aspirated is rooted in earlier work such as Halle & Stevens 1971, which represents those segments with [+spread glottis].[4]

The analysis advanced in this dissertation will ultimately deviate from Lombardi's conclusion in arguing that we do in fact need a [-voice] specification and therefore a binary rather than privative feature system; however, the observation that voicelessness seems to be unmarked for obstruents but marked for sonorants is both relevant and important. In particular, the marked status of voicelessness in vowels means that unlike obstruent devoicing, vowel devoicing cannot be viewed as neutralization to an unmarked default, nor can it be accounted for by simply delinking a laryngeal feature or node. Rather, as stated at the beginning of this section, the value of a laryngeal feature must be changed, or a laryngeal feature must be added.

[4]Additionally, while the more recent work on laryngeal representations has focused on consonants, Halle & Stevens 1971 include voiceless and breathy vowels in their proposal.

Binary [voice]

While privative laryngeal features have been relatively widely accepted, some work still assumes or argues for a binary system. A recent explicit argument in favor of binary rather than privative laryngeal features is seen in W. G. Bennett & Rose 2017, which presents an analysis of voicelessness dissimilation in Moro. The authors show that in Moro, an underlyingly voiceless (obstruent) consonant becomes voiced when it is followed by a vowel and then another voiceless consonant (i.e. _VC̥, where C̥ indicates a voiceless consonant). They argue that a system with privative [voice], in which the voiceless consonants are unspecified for laryngeal features, cannot account for this process, because there would be no phonological feature available to trigger the dissimilation. Instead, a [-voice] feature value must be specified so that it may participate in, or trigger, the phonological process in question. Bennett and Rose also consider the possibility that the apparent voicing contrast in Moro consonants is, in fact, a [spread glottis] contrast, and that the dissimilation process targets the feature [spread glottis] rather than [-voice]. They reject this alternative analysis, however, on the basis of phonetic evidence. Specifically, they conducted an acoustic study comparing the realization of Moro voiced and voiceless stops, and found prevoicing corresponding to the voiced segments, and short-lag VOT corresponding to the voiceless ones. On the basis of this finding, they argue that the difference between the two types of consonants is better characterized by a (binary) [voice] contrast than by a [spread glottis] contrast.

The crucial issue for this dissertation, like for the analysis of Moro dissimilation, is that if [voice] is privative, the [-voice] specification does not exist, and it is therefore not available as a target for a process of vowel devoicing. If [-voice] is not an available for the representation of voiceless vowels, the only option is to define them with the feature [spread glottis], along the lines of Lombardi's solution for sonorant consonants. However, it will be seen in later chapters of this dissertation that while [spread glottis] can account for, and is in fact needed for, some processes of vowel devoicing, it is not sufficient for the analysis of all vowel devoicing patterns found cross-linguistically. Rather, a [-voice] specification is ultimately required for a complete account of the distribution of voiceless vowels in some languages. In this way, vowel devoicing provides a new challenge to a privative feature model, and instead supports a binary system in which both "+" and "-" values of [voice] may be specified and thus targeted by phonological processes.[5]

1.3 Prosodic structure and its interactions with segmental phonology

It is quite common for segmental phonological processes to be sensitive to prosodic structure. Vowel devoicing processes are no exception, and in fact, exhibit several types of interactions between prosodic structure and segmental phonology cross-linguistically, which will be articulated in greater detail in Chapters 3-5 of this dissertation. As will be seen, in some cases, the application of vowel devoicing, which is understood here to be a segmental process (i.e. change in featural specification of a segment), is determined solely by prosodic position. Specifically, in these cases, VD is triggered in particular weak positions, such as the right edge of a prosodic domain. In other cases, vowel devoicing is triggered in the same types of weak positions, but only when the vowel is also adjacent to a given type of consonant, indicating an

[5]It should be noted that while this dissertation provides evidence only that [voice] must be binary, for consistency, I use a binary notation for the [spread glottis] feature in the analyses in subsequent chapters as well (specifically, [+spread glottis]). However, the proposal does not depend one way or another on the nature of [spread glottis].

additional level of interaction between prosodic structure and segmental phonology. Finally, there are still other cases in which the application of vowel devoicing is determined primarily by the segmental environment and relatively unrestricted by prosodic structure; however, specific prosodically strong positions like stressed syllables can block these processes if the segmental conditioning environments happen to arise in those specific structural positions.

Since such interactions are fundamental to the development of the vowel devoicing typology and the formal analysis presented later in this dissertation, I review next some basic theoretical considerations and assumptions about prosodic structure and the ways it interacts with segmental material. I focus on and highlight those aspects of the interactions that will be most relevant for my analysis of vowel devoicing in the coming chapters.

1.3.1 Prominence relations

Prosodic structure refers to both i) the grouping of phonological material into hierarchically organized constituents between the syllable and the utterance, and ii) the prominence relations within those constituents (e.g., Nespor & Vogel 1986, 2007; Selkirk 1980). The focus of this dissertation is the latter, which can be understood in terms of the relative strength or weakness associated with different positions in words and phrases. As will be seen in subsequent chapters, both prosodic strength and weakness can have their own direct effect on vowel devoicing.

One basic type of prominence relation within prosodic structure results from headedness, often assumed to be a universal property of prosodic constituents. Conditions on headedness have been viewed in different ways. The stricter approach, which is assumed for this dissertation, requires that each non-terminal prosodic constituent (n) contain a head constituent of the immediately lower level (n-1), which is more prominent than all other sub-constituents within that larger domain (n). (Martínez-Paricio 2013; Zec 2003).[6] The prominence relations within prosodic constituents can therefore largely be attributed to the relationship between the "strong" head and "weak" non-head elements. Within the foot and the word, headedness is typically manifested as "stress." This is an abstract property, and languages may differ in how they manifest it on the surface. Such surface manifestations, however, are crucial in identifying stress in a language. While canonically, stress is associated with suprasegmental correlates relating to pitch, duration, and intensity, language-specific segmental patterns are also often taken as evidence for headedness, prominence, or foot structure. (For segmental evidence for these structures, see among others, Costa 2003 on Miami-Illinois, R. Vogel 2020, 2021 on Cheyenne, and the cross-linguistic investigations in Hayes 1995, González 2003, Vaysman 2009, and R. Bennett 2012.)

The other basic type of prominence arises from positions relative to the edges of prosodic constituents. Specifically, domain-initial positions are taken to be prominent, or strong, relative to non-initial positions. Domain-final positions have been found to exhibit somewhat mixed behavior (a combination of weak and strong properties) both cross-linguistically and in some cases within a single language (see discussions in Barnes 2006 and R. Walker 2011 among others). As will be seen in this dissertation, when domain-final positions exhibit specific effects with regard to vowel devoicing, they must be characterized as non-prominent (i.e. weak).

[6] A weaker approach to headedness simply requires that each non-terminal prosodic constituent contain at least one constituent of the immediately lower level (e.g., Itô & Mester 1992; Selkirk 1996). This version does not actually require that all prosodic constituents contain a head (R. Bennett 2012).

1.3.2 Segmental phonology in strong vs. weak prosodic positions

The prominence relations introduced above are relevant not only to prosodic structure itself but, crucially for this dissertation, also to segmental phonology. In fact, the cross-linguistic survey conducted for this dissertation reveals that prominence relations associated with both headedness and edges of prosodic constituents play important roles in vowel devoicing. The most common interactions between prosodic structure and VD involve domain-final and stressed syllables, which exhibit opposite effects, corresponding to prosodic weakness and strength respectively. The immediately pretonic syllable, which I analyze as the non-head syllable of a foot, and domain-initial syllables play a role as well, but only in a handful of languages. (See Appendices B-E for inventories of these interactions and the languages in which they occur.)

More broadly within phonology, the segmental manifestations of prosodic prominence relations may be seen to involve reference to either of two levels of phonological representation. First, different prosodic positions are found to prefer different types of segmental material in the surface form (or the output, in Optimality Theory terms). Second, segments in different types of prosodic positions are found to exhibit different relationships to their underlying representations (or the input, in Optimality Theory terms).

It should be recalled from earlier in this introduction that voiceless vowels are never contrastive. That is, they do not exist at the underlying level of phonological representation. They do, however, appear in surface (output) forms, often restricted to specific prosodic positions. Therefore, the relationship between prosodic structure and the distribution of voiceless vowels must be seen as the first type of segmental manifestation of prosodic prominence, in which different prosodic positions exhibit different preferences for specific types of segmental material in the surface or output form. In the rest of this subsection, I provide additional background on this type of prosodic effect on segmental phonology. Then, in the next subsection, I outline the means of accounting for these positional effects within Optimality Theory, and in particular, the way that I will account for the specific types of positional effects seen in the context of vowel devoicing.

Regarding relationships to surface forms, it is often observed that different types of segments or segmental properties tend to be preferred in strong vs. weak prosodic positions. For instance, vowels in prosodically strong positions tend to be longer and more sonorous (e.g., low vowels preferred to high vowels in strong positions). By contrast, vowels in weak positions tend to be shorter and less sonorous. Consonants in strong positions tend to be voiceless, aspirated, and/or relatively long, and tend to exhibit stronger constrictions, associated with lower sonority (e.g., stops or fricatives preferred to approximants). Consonants in weak positions, on the other hand, tend to be voiced and exhibit relatively weak constrictions, associated with higher sonority. From the perspective of Optimality Theory, these effects are collectively referred to as positional markedness, since they reflect requirements of output forms just as other markedness constraints do.

While the focus here is on the surface preferences seen in different prosodic positions, it is useful to contrast these effects with those in which segments in different prosodic positions exhibit different relationships to the underlying representation. With regard to the latter, prosodically prominent, or strong, positions, such as stressed syllables and word-initial positions, are known to exhibit a number of clearly identifiable effects, which, from the perspective of Optimality Theory, are attributed to a greater degree of faithfulness to the input. Specifically, strong positions are seen to i) maintain segmental contrasts that are neutralized elsewhere, ii) block certain phonological processes that occur elsewhere, and iii) trigger phonological processes that affect segments in other, less prominent positions (e.g., Beckman 1998). These effects are collectively referred to as positional faithfulness.

Crucially, while positional faithfulness always causes segments in strong prosodic positions to resist or block phonological processes that may occur elsewhere, positional markedness can both trigger specific phonological processes that are limited to one prosodic position and block phonological processes that occur elsewhere. For example, in Zabiče Slovene, low sonority nuclei are disfavored in stressed syllables, and this, in turn, triggers a process whereby underlying high vowels are lowered to mid vowels in those syllables (Crosswhite 1999; J. Smith 2002). Since this process is driven by a specific surface preference in stressed syllables, it does not occur outside those positions. Similarly, in a number of languages investigated in this dissertation, a surface preference for voiceless vowels in domain-final syllables triggers vowel devoicing only in those environments. On the other hand, there is another type of vowel devoicing also investigated in this dissertation that is triggered adjacent to voiceless or aspirated consonants in essentially any prosodic position. A surface dispreference for voiceless vowels in stressed syllables, however, consistently blocks these processes only in that one specific prosodic position.

1.3.3 Interactions between prosodic structure and segmental phonology in Optimality Theory

Optimality Theory offers a clear and insightful means of accounting for the interactions between prosodic prominence relations and segmental phonology with the use of positional constraints. Such constraints are composed of a basic markedness or faithfulness constraint and an indication of the type of prosodic position to which the constraint is relativized.

In Chapters 4 and 5 of this dissertation, I will argue that the distinct roles of prosodically strong and weak prosodic positions in determining the distribution of vowel devoicing require two sets of positional markedness constraints: one that disprefers voiceless vowels in specific strong positions (e.g., *V[+spread glottis]/ˈσ, prohibiting [+spread glottis] specifications for vowels in stressed syllables) and another that prefers voiceless vowels in specific weak positions (e.g., V[+spread glottis]/$]_{\omega}$, requiring [+spread glottis] specifications for vowels at the right edge of a word). This is in contrast to prior work on positional markedness, such as J. Smith 2002, which proposes to limit the set of possible positional markedness constraints to those that ensure, or further enhance, perceptual salience in strong positions, an effect Smith refers to as "phonological augmentation." However, as I will demonstrate in Chapters 4 and 5, neither positional effect on vowel devoicing (weak or strong) can be merely reduced to an indirect consequence of the other. That is, in addition to the constraints that serve to enhance the perceptual salience of segmental material in strong positions as discussed by Smith, languages may also require separate constraints that have the opposite effect in specific weak positions. This second type of effect may be understood conceptually as a means of reducing the perceptual salience of segmental material in those positions.

In accounting for the range of phonological VD phenomena identified in my cross-linguistic survey, I therefore introduce a new set of constraints. However, their structure and interaction with other constraints largely conforms to Smith's implementation of her positional markedness constraints. An example of this approach can be seen in Smith's analysis of word-initial fortition of liquids to stops (e.g., /r/ → [t]) in Kuman. She accounts for this pattern with a positional markedness constraint [*Onset/R]/σ_1 that prohibits liquid onsets in the word-initial syllable. (Recall that, as discussed above, consonants with stronger constrictions tend to be favored in strong prosodic positions.) The crucial ranking in this case is [*Onset/R]/σ_1, Max-seg, Dep-seg >> Ident[f]. That is, the observed fortition satisfies the positional markedness constraint, and since it requires changing a single phonological feature, it only violates the lower ranked Ident[f]. Note that while deletion or epenthesis of a segment could also satisfy the positional markedness constraint, these alternative strategies would result in the violation of a higher ranked faithfulness constraint. Just as the ranking of positional markedness relative to various faithfulness constraints determines the means by which the positional markedness constraint is satisfied in Kuman (fortition rather than epenthesis or deletion), I will show in Chapters 4 and 5 how different rankings between positional markedness and key faithfulness constraints result in different versions of vowel devoicing.

1.4 Contributions and outline of this dissertation

The main contributions of this dissertation are three-fold. First, from an empirical perspective, it presents the product of a large-scale cross-linguistic survey of vowel devoicing processes in the form of the Vowel Devoicing Database (Appendices A-E), which contains information about each VD process examined, as well as how each process fits into the larger phonological system of the language in which it appears. This information not only constitutes the foundation of the analysis developed in this dissertation, but it also offers a basic resource for others interested in additional investigations of vowel devoicing.

Second, this dissertation provides a systematic phonological analysis of vowel devoicing. As such, it addresses a lacuna in previous research, which has focused primarily on the phonetic mechanisms and realizations of vowel devoicing. On the basis of the information presented in the Vowel Devoicing Database, I develop a phonologically informed typology on the one hand, and a formal phonological account of cross-linguistic patterns of vowel devoicing within the framework of Optimality Theory, on the other. In this context, it should also be noted that the most common targets of phonological typology thus far have been inventories or distributions of specific types of segments (e.g., consonants, vowels), inventories and classifications of non-segmental elements (e.g., tone, stress), and inventories of prosodic structures below the word (e.g., syllable shapes). Less research has focused on the distribution and classification of specific phonological phenomena or processes from a typological perspective. A notable exception to this is Jeff Mielke's P-base, which compiled a large number of phonological rules across the world's languages. (See discussion in Brohan & Mielke 2018.)[7] The phonological typology of vowel devoicing processes developed in this dissertation therefore also contributes to filling a gap in the typology literature.

As will be seen, the typological model of vowel devoicing advanced in this dissertation focuses on the distinct roles of prosodic and segmental conditioning

[7] See also Gordon 2016 for a general discussion of phonological typology, and his Chapter 5 in particular for discussion of segmental processes.

factors, which I treat as two separate parameters. Specifically, cross-linguistic patterns reveal that these parameters can operate independently, yielding processes that are triggered only by a particular prosodically weak position or only by a particular segmental environment. Additionally, the parameters may interact, yielding processes that are triggered by a combination of the two types of factors (i.e. processes that occur only in a particular weak position given the right segmental environment). All three scenarios are well-attested across the world's languages, as shown in Table 1.1 below, modified from a table in Chapter 3. Crucially, for a complete phonological account of vowel devoicing, this requires distinct prosodic and segmental mechanisms, as well as a means for these mechanisms to interact.

	Segmental trigger		**No segmental trigger**	
	number	percent	number	percent
Prosodic trigger	13	18.6%	22	31.4%
No prosodic trigger	35	50%	–	–

Table 1.1: Total number and percentage of processes in the Vowel Devoicing Database triggered by a specific prosodically weak position, a specific segmental environment, and by a combination of the two.

Based on the generalizations offered by the typology, I develop a formal phonological account of vowel devoicing within the framework of Optimality Theory, in which I attribute the two distinct mechanisms to two different types of markedness constraints satisfied by devoicing vowels in certain contexts. The prosodic mechanism is attributed to positional markedness constraints that require vowels to be voiceless in certain prosodically weak positions such as the right edge of a word or a phrase. In contrast, the segmental mechanism is attributed to markedness constraints that require certain laryngeal features associated with voiceless or aspirated consonants to be shared between multiple segments, causing an adjacent vowel to devoice via feature spreading. As will be seen, apparent interactions between these two mechanisms can then be attributed to different rankings between one of these two major types of constraints and other markedness and faithfulness constraints within a larger phonological system.

Third, the phonological focus of this investigation leads to insights and contributions to our understanding of several broader issues in phonological theory. In particular, the vowel devoicing phenomena and analysis presented here provide information that bears directly on Feature Theory, especially the nature of laryngeal features, an issue previously informed primarily by consonant phonology. They also provide additional information and perspectives regarding the nature of interactions between prosodic structure and segmental phonology. Finally, the analysis developed for domain-final vowel devoicing in particular indicates that the concept of domain generalization, often associated with domain-final obstruent devoicing, plays a fundamental role in vowel devoicing as well. Furthermore, it indicates ways in which this concept may be adopted more generally in other phonological analyses.

The rest of this dissertation is structured as follows. Chapter 2 provides a more thorough introduction to vowel devoicing, contextualizing voicelessness within the larger picture of non-modal phonation in vowels and outlining the major approaches taken to studying vowel devoicing in the existing literature. I highlight major takeaways from this literature, including the importance of both prosodic and segmental conditioning factors in the distribution of vowel devoicing cross-linguistically, as well as the relative dearth in the literature with regard to both phonological and typological perspectives.

Chapter 3 introduces the Vowel Devoicing Database derived from the cross-linguistic survey of vowel devoicing processes conducted for this dissertation, and develops a typology of the processes focusing on the different roles of segmental and prosodic conditioning factors. This typology identifies three major categories of vowel devoicing: i) (purely) Segmentally Restricted VD, ii) (purely) Prosodically Restricted VD, and iii) Prosodically and Segmentally Restricted VD. Finally, this chapter identifies several finer-grained patterns with regard to the specific types of segmental material and prosodic structures that are relevant for vowel devoicing across the Database.

Chapter 4 proposes an formal phonological account of each type of vowel devoicing identified in the typology within the framework of Optimality Theory. This analysis shows which types of variation found across processes require fundamentally distinct types of analysis, reflecting different underlying phonological mechanisms, and which types of variation can be reduced to differences in constraint ranking. This, in turn, allows for the unification of two of the categories of devoicing identified in Chapter 3 (the two prosodically restricted categories). It also introduces the idea that the different roles of strong and weak prosodic positions must be accounted for with two different types of positional markedness constraints.

Next, Chapter 5 explicitly addresses a number of implications of the Vowel Devoicing Database and typology for theoretical issues in phonology. These are the nature of laryngeal features, the nature of the interactions between prosodic structure and segmental phonology, and the ways in which phonologization and domain generalization may influence the distribution of phonological processes.

Finally, Chapter 6 reviews the major findings of this dissertation and their broader implications, and notes several issues that call for further investigation.

CHAPTER 2

NON-MODAL PHONATION IN VOWELS AND PRIOR LITERATURE ON VOWEL DEVOICING

The previous chapter provided theoretical background on several key phonological issues to frame the assumptions and theoretical contributions of this dissertation. This chapter presents the necessary phenomenon-specific background concerning vowel devoicing itself. Specifically, Section 2.1 presents a brief overview of phonation types, situating voicelessness in the larger picture of phonation in phonological systems. Next, Section 2.2 reviews the major themes addressed in prior work on vowel devoicing. Finally, Section 2.3 reviews the major generalizations that emerge from the prior literature on vowel devoicing. This section also highlights several issues that remain, requiring further examination in order to develop a more complete understanding of the phonological nature of vowel devoicing cross-linguistically.

2.1 Non-modal phonation in vowels

This dissertation focuses on processes of vowel devoicing, which involve a type of nonmodal phonation. To put VD in context, therefore, this section briefly discusses phonation types more generally. In particular, I provide an overview of the articulatory and acoustic properties of different types of phonation and their phonological distributions in vowels. Figure 2.1 presents a standard, though simplified, representation of the relationship between different glottal states and the most common types of phonation, or voice quality (i.e. the sound produced by the vocal folds).

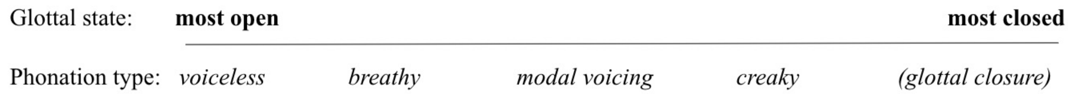

Figure 2.1: Simplified representation of phonation categories (from Gordon & Ladefoged 2001, p. 384; based originally on Ladefoged 1971).

As can be seen in Figure 2.1, phonation categories can be treated as points along a continuum. Voicelessness, on the far left, is associated with an open glottis position, and no vibration of the vocal folds. At the other end, on the far right, we find complete glottal closure (i.e. a glottal stop), which also does not involve vibration of the vocal folds, but in this case, it is due to the fact that no air can pass through them (Ladefoged 1971). The three categories between voicelessness and a glottal stop involve some degree of constriction and vibration of the vocal folds, thus resulting in various types of voicing. These categories are defined relative to each other rather than in absolute terms corresponding to categorically different states of the glottis. Modal voice, in the middle, is generally considered the 'normal' or default state of the glottis associated with 'typically' voiced vowels. The other two voicing categories are described in comparison to modal voice both articulatorily and acoustically (e.g., Garellek 2019; Gordon & Ladefoged 2001; Ladefoged 1971). Breathy voice, the category to the left of modal voice in the figure, involves a relatively small degree of constriction, resulting in turbulent airflow through the glottis and vibration of the vocal folds without the vocal folds actually coming together (Gordon & Ladefoged 2001; Ladefoged 1971). In creaky voice, on the other hand, the category to the right of modal voice, the glottis is mostly closed, but there is enough of an opening in a portion of the vocal folds for some airflow and voicing to occur, resulting in irregularly spaced glottal pulses (Gordon & Ladefoged

2001; Ladefoged 1971).[1] Most of the phonation categories shown on the continuum may apply to both vowels and consonants; however, languages differ in which they use, and whether they use them contrastively or allophonically.

As far as vowels are concerned, voicelessness is considered one of three types of nonmodal phonation, the other two being breathy and creaky voice (Gordon 1998). Voiceless vowels differ from the other two categories of nonmodal vowels, however, in two fundamental ways. First, voiceless vowels are the only ones that do not involve any voicing or vocal fold vibration at all. Second, they exhibit a fundamentally different phonological distribution. While there is robust evidence for contrastive breathy and creaky voice in vowels cross-linguistically (e.g., Jalapa Mixtec, which exhibits a three-way phonation contrast among breathy, modal, and creaky vowels), contrastive voiceless vowels are rare, if not actually nonexistent (Gordon & Ladefoged 2001; Ladefoged & Maddieson 1990). In the few languages for which phonemic voiceless vowels have been posited, however, no evidence has been provided that demonstrates that they do in fact exist in contrastive distribution with corresponding (modal) voiced vowels. (E.g., in Turkana, voiceless vowels have been described as phonemic but appear only phrase-finally, in complementary distribution with voiced vowels, Dimmendaal 1983.) Crucially, I therefore assume in this dissertation that all voiceless vowels are allophonic or phonetic. They do not appear in underlying representations or as phonemes, but rather may only arise as a result of phonological or phonetic processes of vowel devoicing.

The distribution of voiceless vowels appears to diverge from that of the other two types of nonmodal vowel phonation in yet another way. Not only are voiceless vowels different in that they are limited to allophonic status whereas breathy and

[1] There are additional complexities to the articulations of nonmodal voicing, especially with regard to creaky voice, but these are not relevant to the present focus on voiceless vowels.

creaky voice can be contrastive or allophonic, but allophonic voicelessness also differs from allophonic breathy and creaky voice with regard to the types of vowels that tend to exhibit them. Specifically, allophonic breathy and creaky voice both occur more frequently in longer vowels, and in such vowels, they often affect only a portion of the full vowel duration. For example, in Quileute, creaky voice spreads from consonants only to stressed long vowels, which presumably are the vowels with the longest duration in the language (Powell & Woodruff 1976). In Hupa, creaky and breathy phonation both spread from syllable-final consonants only to preceding long vowels, and the spreading has been reported to affect only about 40% of those vowels (Gordon 2001; Gordon & Ladefoged 2001). In contrast, vowel devoicing occurs most frequently in vowels with the shortest durations. Thus, in languages with contrastive vowel length, devoicing tends to target short but not long vowels. Moreover, devoicing affects high vowels more frequently than low vowels, attributed to the fact that low vowels typically have intrinsically longer durations than high vowels. These patterns are observed both within a single language and cross-linguistically (Gordon 1998; Greenberg 1969).

Despite the differences between voiceless vowels and the other types of nonmodal vowels, there are some general properties that hold for all nonmodal phonation in vowels that may also be noted. Most importantly for the present investigation is that nonmodal vowels tend to be less acoustically salient, and correspondingly, less perceptually salient than modal vowels. In the absence of vocal fold vibration, voiceless vowels in particular do not present an f0, or fundamental frequency. Consequently, there is considerable reduction in the recoverability of pitch and vowel quality distinctions in voiceless vowels relative to voiced, especially modal, vowels (Gordon 1998; Gordon & Ladefoged 2001).

2.2 Previous work on vowel devoicing

Despite being phonologically marked and often considered relatively rare (Gordon 1998; Tsuchida 2001), (surface) voiceless vowels are attested across a genetically and geographically diverse set of languages including in East Asia, South Asia, Oceanea, Europe, Africa, the Middle East, and North and South America (Greenberg 1969). The most well-studied topic within of vowel devoicing to date is the phonetics and phonology of Japanese High Vowel Devoicing (dating back to Han 1962 and McCawley 1968); however, there are also some studies that discuss vowel devoicing in other languages as well. The prior literature on vowel devoicing generally addresses the phenomenon from one of several different perspectives. These include i) descriptive phonetic studies of the realization of devoiced vowels in a single language, ii) statistical analyses of the distribution of vowel devoicing within a single language, iii) broad surveys of vowel devoicing patterns across a relatively large number of languages, and iv) phonological analyses of vowel devoicing within a single language or a small set of languages. In the rest of this section, I provide a brief overview and examples of each type of approach. All of the languages featured in this section are included in the larger set of languages comprising the Vowel Devoicing Database developed for this dissertation (see Chapter 3 and Appendices).

2.2.1 Descriptive phonetic studies

The first category of vowel devoicing literature consists of descriptive phonetic studies of VD within individual languages. Descriptive acoustic studies have been applied to a relatively diverse set of languages, including, but not limited to, Greek (Dauer 1980), Japanese (e.g., Kondo 1994; Tsuchida 1997), and Southern Ute

(Oberly & Kharlamov 2015). This body of research takes into account several acoustic dimensions, and reveals some degree of variation in the realization of voiceless vowels. For instance, Oberley and Kharlamov find that devoiced vowels in Southern Ute can be realized as fully voiceless or partially voiceless. In other cases, they may appear to be missing altogether, but can be observed indirectly, for example in coarticulation effects on the preceding consonant (the syllable onset), including increased duration, reduced intensity, and devoicing.

There are also some phonetic studies that investigate articulatory properties of voiceless vowels, in particular, glottal, labial, and tongue movements during the production of the vowels. These include Tsuchida 1997 and references therein who investigate glottal movement and the degree of abduction of the vocal folds during devoiced vowels in Japanese. Additionally, Shaw and Kawahara (2018, 2021) and Iwasaki, Roon, Shaw, and Whalen (2020) investigate tongue movement during devoiced vowels in Japanese. In a more multifaceted study, Gick, Bliss, Michelson, and Radanov (2012) examine not only the positions and movements of the tongue and lips in Blackfoot and Oneida during the articulation of devoiced vowels, but also their acoustic properties, as well as the perception of the same vowels.

2.2.2 Statistical analyses of the distribution of vowel devoicing

Another approach to vowel devoicing that has been applied to a relatively large and diverse set of languages involves the statistical analysis of the factors that influence the distribution of VD within a specific language. In general, this approach may be seen as part of a larger trend in laboratory phonology studies, which takes advantage of large datasets drawn from experiments and naturalistic corpora. The data are typically analyzed using statistical methods including (but not limited to) logistic or linear regression in order to identify significant factors in the categorical application of some process, or in more continuous measures of the phonetic realization or manifestation of a phenomenon.

In the context of vowel devoicing, statistical studies have used spoken corpora and experimental data to investigate the role of various factors in the application of VD in a particular language. These include studies on Greek (Dauer 1980; Kaimaki 2015), Turkish (Jannedy 1995), French (Torreira & Ernestus 2010), Cochabambino Spanish (Sessarego 2012), Japanese (Kilbourn-Ceron & Sonderegger 2018; Maekawa & Kikuchi 2005), and Brazilian Portuguese (J. Walker & Mendes 2019), all of which have been seen to exhibit some degree of variability in the application of vowel devoicing. The factors typically examined in these studies include phonological properties such as segmental and prosodic environments, as well as a range of non-phonological variables including speaking rate, lexical frequency, and social identity of the speaker.

Beyond simply identifying the significant factors that contribute to vowel devoicing patterns, another use of the statistical type of study has been to distinguish between multiple VD processes in a single language. For instance, in their analysis of Japanese, Kilbourn-Ceron and Sonderegger propose a distinction between two types of vowel devoicing: one occurring between a voiceless consonant and the right edge of a prosodic boundary, and the other occurring word-internally between two voiceless consonants. This is based on their finding that vowel devoicing in the former environment but not the latter exhibits variability and is subject to speaking rates and lexical frequency effects. The authors suggest that this reflects a difference between lexical and post-lexical processes, and thus the two types of VD processes must be considered distinct.

2.2.3 Cross-linguistic surveys of vowel devoicing

The third type of research on vowel devoicing discussed here is much less common than the first two types. This category involves the investigation of cross-linguistic patterns of vowel devoicing to permit the formulation of generalizations regarding the distribution of these processes across the world's languages. The two major studies in this category are Greenberg 1969 and Gordon 1998, both of which include approximately 50 languages that exhibit VD phenomena. These studies present descriptive generalizations and develop implicational universals that pertain to the vowels that undergo devoicing themselves, and/or to the environments in which vowels are observed to devoice.

Regarding the quality and length of the vowels themselves, Greenberg and Gordon both report that high vowels devoice more often than low or mid vowels. Moreover, short vowels devoice more often than long vowels. The effect of length not only applies to languages that contrast short and long vowels, but can also be seen at a more phonetic level in relation to the first point. That is, the tendency for high vowels to devoice more frequently than low vowels is attributed to the former typically being intrinsically shorter than the latter.

Both observations regarding the distribution of voiceless vowels may also be viewed in terms of implicational universals. For instance, Greenberg found that the presence of devoiced mid vowels in any given language implies the presence of devoiced high vowels in that language, and the presence of devoiced low vowels implies the presence of devoiced mid/high vowels. Similarly the presence of devoiced long vowels implies the presence of devoiced short vowels.

Vowel devoicing has also been observed to exhibit important distributional patterns with regard to suprasegmental properties, in particular stress and tone. The most notable of these patterns is that stress appears to consistently block VD. According to Greenberg, no language actually has voiceless stressed vowels. Gordon's position on the role of stress in vowel devoicing is similar but a bit weaker, leading him to the following implicational universal: no language will devoice stressed vowels without devoicing unstressed vowels. Thus, according to Gordon, a language may devoice stressed vowels, but this implies devoicing of unstressed vowels.

Regarding tone of devoiced vowels, both Greenberg and Gordon observed that vowels with high tone tend to devoice less frequently than those with low tone, and in fact, in some languages, only vowels with low tones may devoice (e.g., Cheyenne, Acoma). Again this pattern may be expressed in terms of an implicational universal to the effect that if a language devoices vowels with high tone, it also devoices vowels with non-high tones.

In addition to providing descriptive observations, Gordon (1998) grounds his typological generalizations in insights from phonetics. Specifically regarding the phonetic mechanism responsible for vowel devoicing, he attributes devoicing found adjacent to voiceless consonants to articulatory overlap between i) the glottal adduction gesture associated with a typical phonologically voiced vowel and ii) the glottal abduction gesture associated with the adjacent voiceless consonant (following Dauer 1980; Jun & Beckman 1993, 1994 and others). Gordon then extends this perspective to account for the rarity of devoiced long vowels as well as the fact that high vowels devoice more often than low vowels. The key to understanding both patterns is the assumption that the shorter a vowel is, the more affected it is by gestural overlap. Thus, phonemically short vowels are more affected than phonemically long vowels, and inherently shorter high vowels are more affected than inherently longer low vowels. Moreover, with regard to an observation that vowel devoicing is particularly prevalent at the ends of large prosodic domains like phrases and utterances (also addressed in Greenberg 1969), Gordon introduces consideration of aerodynamic factors in speech (following Dauer 1980). In particular, he notes that since subglottal air pressure decreases over the course of an utterance, it is more difficult to maintain voicing toward the end of that domain, or other relatively large domains. The consequence is the greater prevalence of vowel devoicing at the right edge of phrases and utterances.

While Gordon observes that in some languages, vowel devoicing processes may be phonological, (see Section 1.1 of this dissertation for specific types of evidence for phonological rather than phonetic VD), he assumes that both phonetic and phonological versions of vowel devoicing occur in similar environments and thus may be accounted for by the same generalizations, and grounded in the same phonetic factors. Some issues with this assumption will be discussed in detail in Section 5.3 of this dissertation.

Given the role that Gordon attaches to phonetic aspects of all vowel devoicing processes, it is unsurprising that he does not attempt to draw a clear line between phonetic and phonological versions of VD processes in his paper. He also does not suggest any other major distinctions between different types of vowel devoicing. In this respect, his approach shares additional commonalities with that of Greenberg. That is, both researchers identify cross-linguistic variation in VD processes, but at the same time, they ultimately view them as variants of the same basic phenomenon. This is a crucial difference from the analysis and typological model developed in subsequent chapters of this dissertation, which will classify vowel devoicing processes into distinct categories along two different dimensions, as well as from some of the other prior literature on vowel devoicing discussed in the rest of this chapter.

A somewhat different perspective is presented in a third, more recent, cross-linguistic study of vowel devoicing (Chitoran & Marsico 2010), which surveyed 39 languages. In contrast to the approaches of Greenberg and Gordon, Chitoran and Marsico's work is centered around a proposed dichotomy between two distinct types of devoicing based not on the properties of the vowels themselves, the adjacent segments, or articulatory mechanisms, but rather on the positions of the vowels in a particular prosodic domain. That is, Chitoran and Marsico propose that what is crucial for distinguishing vowel devoicing phenomena is whether they apply in contexts referred to as "non-positional" (essentially domain-internal) or in contexts referred to as "positional" (domain-final).

Finally, it is important to note a generalization concerning the environments in which vowels devoice cross-linguistically. It has generally been observed that both segmental and prosodic environments play crucial roles in the distribution of voiceless vowels. In fact, in the studies of both Greenberg and Gordon, it was found that VD is subject to considerable restrictions in relation to both types of properties. Specifically, it was noted that with regard to the segmental context, voiceless vowels typically appear adjacent to a voiceless consonant, and with regard to the prosodic context, they tend to appear preceding a prosodic boundary. What has not been addressed, however, is the precise ways in which the segmental and prosodic properties interact, and what their interactions mean for the underlying mechanisms of vowel devoicing. It is precisely this issue that underlies the research of this dissertation.

2.2.4 Phonological analyses of vowel devoicing

Finally, there have been relatively few more theoretical phonological analyses of vowel devoicing. The analyses in this category vary somewhat but all the relatively recent phonological studies make use of a combination of phonological constraints and either autosegmental or gestural representations. They tend, moreover, to focus on one, or a small number of languages.

For instance, Cho (1993) provides an account of vowel devoicing in two languages, Comanche and Acoma. She considers these to be phonological phenomena, and crucially relies on autosegmental spreading of the [spread glottis] feature from /s/ and /h/ to an adjacent vowel in her analysis. She further proposes various constraints that prevent feature spreading in certain segmental, tonal, and prosodic environments. Interestingly, she also draws a dichotomy between VD processes like those in Comanche and Acoma and VD processes in some other languages like Woleaian, Papago (Tohono O'odham), and Japanese. The crucial difference for Cho is that the latter must be considered phonetic rather than phonological.

The case of Japanese raises interesting questions, however, and other authors have proposed that at least some vowel devoicing in that language requires a phonological analysis. For example, Tsuchida (1997, 2001) argues that Japanese exhibits both phonetic and phonological processes of vowel devoicing and develops an Optimality Theoretic analysis of the phonological pattern. (The phonetic pattern does not fall within the scope of a phonological (OT) analysis.) In particular, Tsuchida argues that phonological VD in Japanese arises from a [spread glottis] feature that either spreads from a consonant to the vowel, or gets inserted onto the vowel in certain contexts. The outcome is that high vowels devoice between two adjacent voiceless consonants. Tsuchida accounts for additional segmental and tonal factors that may inhibit vowel devoicing under certain circumstances with additional constraints, as Cho does for Comanche and Acoma.

Another phonological analysis of vowel devoicing is that of Delforge (2008) for Andean Spanish. Delforge argues that glottal gestures rather than laryngeal features are what account for unstressed vowel devoicing adjacent to voiceless consonants in this language. Specifically, she proposes that vowel devoicing arises from the overlap between consonant and vowel gestures in unstressed syllables, and that this is regulated by the phonology. To this end, Delforge's analysis makes use of a combination of Articulatory Phonology-style gestures and Optimality Theory-style constraints, where the constraints essentially coordinate the gestures, following Gafos (2002). The constraints thus create windows of acceptable coordinations, which then allow for some degree of optionality and gradience in the devoicing patterns of the language.

It can be seen in the examination of the existing phonological studies of vowel devoicing that the focus tends to be on processes that occur adjacent to voiceless consonants in non-domain-final positions. While vowel devoicing is common with or without adjacent voiceless consonants at the right edges of words and phrases, there is relatively little (phonological) attention paid to processes in the other environments. A notable exception is Louie (2010), who provides an Optimality Theoretic account of word-final vowel devoicing in Northern Paiute. Her analysis attributes vowel devoicing to the insertion of a [spread glottis] feature on word-final vowels to satisfy an alignment constraint that requires the right edge of a word to be aligned with the right edge of a [spread glottis] feature. Like Delforge (2008), Louie also explicitly allows for both optionality and gradience in devoicing, making use of different types of constraint ranking.

2.3 Key generalizations from the vowel devoicing literature and perspective of the present work

This chapter has reviewed relevant background on non-modal phonation in vowels as well as trends in previous literature on vowel devoicing in order to provide context for the assumptions, investigation, and proposal advanced in this dissertation. The crucial points are briefly summarized here, and important lacunae in the prior literature are identified.

First, it is evident from the review of previous studies that there has been relatively little phonological (compared to phonetic) research on vowel devoicing. There is even less large-scale cross-linguistic work on vowel devoicing, with only three main contributions from this perspective: the early work of Greenberg (1969), and more recent work by Gordon (1998) and then Chitoran and Marsico (2010). The majority of attention has focused, instead, on the surface realizations and patterns of vowel devoicing in specific languages. These include studies of acoustic and articulatory properties of voiceless vowels, as well as their statistical distribution, typically limited to data from a single language.

Second, while most of the phonological, as well as the phonetic, research that does exist has focused on analyzing specific vowel devoicing processes in individual languages, the few cross-linguistic studies have contributed insights based on more general VD patterns observed in a broader range of languages. Given the relatively large number of languages examined in these studies (i.e. up to 50), they focus primarily on the descriptive level, as opposed to the more in-depth phonetic or phonological analyses more feasibly conducted for individual languages. Only by considering a diverse set of languages, however, has it been possible for such studies to formulate broader generalizations about vowel devoicing, concerning the types of vowels and environments that exhibit or disallow VD. These, in turn, inform a number of implicational universals, for example, that the presence of devoiced lower vowels predicts the presence of devoiced higher vowels in a given language, but not vice versa. While Gordon does connect these generalizations to phonetic mechanisms of vowel devoicing, what is still lacking in these cross-linguistic perspectives is an analysis and discussion of the implications for the phonological mechanisms of vowel devoicing, as well as for phonological theory more generally.

Third, examination of the previous vowel devoicing research reveals a gap with respect to possible relationships and interactions among different forms of VD, both within a single language and cross-linguistically. For the majority of the research, the focus on a single language or small number of languages may provide insight into language-specific details, and in some cases, meaningful distinctions between several devoicing patterns, but it is unclear to what extent such analyses could, or should, be generalized to vowel devoicing in other languages. In contrast, the two cross-linguistic studies that examine VD in approximately 50 languages (Greenberg 1969 and Gordon 1998) did not to address possible relationships among different VD processes, or classify particular types of VD processes. Instead, they consider the various VD processes in the languages they survey essentially as variants of the same broad type of phenomenon.

In the few studies that have attempted to draw explicit distinctions between different types of vowel devoicing, this has been done in relation to different properties. In two cases, the distinction was based on the level of phonetics or phonology at which vowel devoicing takes place, separating lexical from post-lexical processes or phonological from phonetic processes. This was done, however, for only a single language or small set of languages (e.g., Cho 1993; Kilbourn-Ceron & Sonderegger 2018). In the other case, the criterion used to distinguish between types of VD was the prosodic position in which the devoicing occurs (Chitoran & Marsico 2010). In this case, questions remain concerning the relationship between the proposed dichotomy and other ways in which vowel devoicing may vary, including in terms of the role of adjacent segments.

Taking into consideration the different types of previous research on vowel devoicing, it is now possible to situate this dissertation within the general domain of vowel devoicing research. Crucially, the present work is a phonological investigation, and thus is not concerned with the phonetic details of the articulation and/or realization of devoiced vowels. Rather, it aims to address lacunae identified above with regard to specific phonological issues that arise in the analysis of vowel devoicing, especially involving the various relationships and interactions between the segmental and prosodic factors that are responsible for vowel devoicing cross-linguistically.

In addition, this dissertation takes a "big picture" approach to vowel devoicing, based on the survey of 70 processes, which permits the formulation of cross-linguistic generalizations. Combined with the focus on the phonological issues of VD, this investigation leads to the development of a phonologically-informed typology of vowel devoicing processes (Chapter 3). It thus bridges the gap between previous phonologically-oriented studies of a small number of VD processes and the few larger typological studies that only consider the presence or absence of VD in different environments across languages, as opposed to more theoretical issues.

As will be seen further in Chapter 3, the approach taken in this dissertation also bridges the gap between the previous approaches that draw dichotomies based on a single dimension of vowel devoicing and those that do not attempt to classify different types of processes at all, by considering and accounting for multiple dimensions along which processes may differ. Finally, it will be demonstrated how the theoretically informed typology developed and discussed in the subsequent chapters has implications for, and provides insight into, not only the phonological mechanisms of vowel devoicing, but also several more general issues relevant to phonological theory, in particular, laryngeal features, and interactions between prosodic and segmental phenomena (Chapter 5).

CHAPTER 3

VOWEL DEVOICING TYPOLOGY

This chapter presents the typological model of vowel devoicing developed for this dissertation. This model reveals meaningful generalizations regarding the phonological distribution of vowel devoicing both within and across the world's languages. These generalizations will then serve as the basis for the formal analysis of VD developed in the next two chapters.

Specifically, the typology that I develop here treats segmental and prosodic conditioning factors as two separate but interacting parameters that govern the application of vowel devoicing. It is clear from previous literature on VD that these processes can be sensitive to both segmental and prosodic conditioning factors, but as shown in Chapter 2, this literature typically either lists each conditioning factor independently or focuses in detail on one type of factor in isolation. In contrast, the approach advanced in this chapter demonstrates that it is necessary to consider not only the individual contributions of prosodic and segmental factors, but also the relationship between these two types of factors in order to understand the full extent of cross-linguistic variation in vowel devoicing and the phonological mechanisms involved in these processes.

Crucially, this approach requires that the typology focus on individual processes rather than languages. This is necessary in particular because some languages exhibit multiple vowel devoicing processes, subject to different segmental and/or prosodic conditions. For example, as will be seen in greater detail later in this chapter and in subsequent chapters, Cheyenne (Algonquian) exhibits three distinct VD processes whose distribution is governed by different combinations of the two parameters: one that devoices phrase-final vowels regardless of the segmental environment, a second that devoices vowels before voiceless fricatives (essentially) regardless of the prosodic position, and a third that devoices word-final vowels before any voiceless consonant (Leman & Rhodes 1978). Thus, the application of the first process is determined by prosodic structure, the application of the second is determined by segmental environment, and the application of third is determined by both prosodic structure and segmental environment. Moreover, the specific prosodic and segmental properties involved vary across these processes. That is, while prosodic structure is relevant for two of the three processes in Cheyenne, these two different processes involve different sized domains. Similarly, the two processes in which segmental environment is relevant involve two different sets of consonants. The role of segmental and prosodic conditioning in each process must therefore be considered in its own right. This approach of focusing on individual processes is consistent with L. M. Hyman (2009)'s proposal that the appropriate way to do (phonological) typology more broadly involves the classification of phenomena, rather than the classification of languages.

As with any typological study, the goal here is to provide insights that apply cross-linguistically (and hold for language broadly), as opposed to accounting for detailed findings about a particular language. To that end, I have examined all vowel devoicing phenomena for which I could find adequate descriptions, even though the information available for different languages is not always consistent or directly comparable. Nevertheless, the fact that clear patterns emerge from the data suggests that the descriptions of VD on which this dissertation is based are sufficiently reliable and comparable to permit the development of a typological model of vowel devoicing.

In the rest of this chapter, I first discuss the cross-linguistic survey of vowel devoicing and resulting Vowel Devoicing Database (VD Database) developed for this dissertation in Section 3.1. I then present the typological model of vowel devoicing in Section 3.2, along with the relevant findings from the Database. Finally, in 3.3, I introduce several more detailed patterns that emerge from the Database concerning the particular types of segmental and prosodic information involved in each parameter of the typology. These patterns will then be discussed further in the remaining chapters.

3.1 Vowel Devoicing Survey and Database

In order to develop the vowel devoicing typology, I conducted a cross-linguistic survey of vowel devoicing based on specific criteria, the results of which are compiled in the VD Database in Appendices A-E. The languages included were identified through broad google and library database searches. The materials consulted include grammatical sketches, phonological work focused on vowel devoicing, phonetic work focused on vowel devoicing, and other materials that include at least a brief mention of vowel devoicing. Additionally, I verified to the extent possible the languages and references in two major cross-linguistic studies (i.e. Gordon 1998; Greenberg 1969).[1]

As noted in the introduction to this chapter, this study treats all processes

[1]In a number of cases, I was not able to locate the sources provided in Greenberg 1969 and Gordon 1998, or any others discussing vowel devoicing in the language in question. In such cases, the language was not included in the VD Database. I also intentionally excluded several processes in the literature for two specific reasons. First, since the purpose of this survey is to develop a phonological typology of vowel devoicing, I did not include processes that are described as being restricted to particular morphemes (e.g., Ayutla Mixtec stem-initial VD, Pankratz & Pike 1967; Quechua VD in high frequency suffixes, Delforge 2011), because their distribution is closely governed by language-specific issues, which would not yield insight into broader, cross-linguistic phonological issues. Second, I excluded processes of VD for which there was little to no discussion of the conditioning environments, since it would not be possible to classify them in the Database and resulting typology (e.g., Zophei VD, the prosodic and segmental conditioning of which the most recent and thorough description leaves to future research (Lotven 2021)).

individually. I identified these processes based on the specific conditioning factors that determine their distribution. Consequently, for any given language, there may be one process, whose distribution is determined by a single consistent set of factors, or several processes, whose distributions are conditioned by several distinct sets of factors. In all cases, each process is treated as its own entry in the VD Database. When several varieties of the same language spoken in different regions are described as exhibiting distinct vowel devoicing processes and/or differences in other relevant phonological properties, I include separate entries for each variety. For example, the Database includes three varieties of Spanish spoken in Bolivia, Ecuador, and Peru, which exhibit distinct VD processes. Similarly, I include three varieties of Oromo, spanning Kenya and Ethiopia, which have different stress and tone systems that interact with their respective VD processes. Ultimately, this yielded 70 processes from 53 languages, spanning 24 language families. The specific processes in each category of VD identified in the typology will be listed in subsequent sections of this chapter. Table 3.1 below summarizes the genetic and geographic spread of the languages included.

Language families	**Geographic regions**
Ainu (1), Algonquian (5), Attic (1), Cushitic (3), Japonic (1), Keresan (1), Khoisan (1), Koreanic (1), Maipurean (1), Malayo-Polynesian (6), Mongolic (2), Muskogean (1), Nakh-Daghestanian (1), Nilo-Saharan (2), Northern Iroquoian (2), Numic (1), Pama-Nyungan (1), Panoan (2), Romance (6), Sino-Tibetan (2), Totonac (2), Turkic (3), Uto-Aztecan (6), Zaparoan (1)	Africa (7), Asia (9), Europe (4), North America (19), Oceania (6), South America (8)

Table 3.1: Language families and geographic regions represented in the Vowel Devoicing Database (number of languages in each shown in parentheses).

For each process, I include the following types of information in the VD Database (assuming the information was available in the sources consulted). The first type is general information about the language in which the process appears, including the language family and region(s) where it is spoken. The second type includes additional relevant information about the phonology of the language itself, in particular, its word prosodic system (e.g., presence/absence of stress and tone), any interactions noted between stress and tone, and any arguments made for more abstract prosodic structure, such as non-stress word prominence or feet. While some of this information is tangential to the main components of the typology developed in this chapter, these details are nevertheless important for our understanding of how each typological category is realized depending on the larger phonological context within a language.

The remaining information included in the VD Database pertains to the vowel devoicing processes themselves. The third type of information comprises the environments in which the VD process occurs (i.e. vowel qualities affected, adjacent segments, positions relative to stress and/or word or phrase boundaries). The fourth type of information is about specific interactions between the VD process and word prosody, such as blocking of VD by stress or tone. The fifth type is information concerning the obligatoriness or optionality of the process, which is not consistently addressed in the sources consulted, but I included it whenever the information was available.

The information in the VD Database is presented in the form of several tables in the Appendices. Specifically, Appendix A presents two tables with information for each language. The first lists each language, the language family, the geographic region where it is spoken, and the main sources I consulted. The second lists each language, the number of processes it contributes to the Database, whether it has stress, whether it has tone (and if tone interacts with stress), and any additional notes concerning relevant issues in the language's phonology and/or with the sources. Appendix B provides one large table listing all 70 processes in the Database. This table includes the language the process is found in, whether it is segmentally restricted, whether it is prosodically restricted, whether it is blocked by any specific prosodic positions or properties, whether it is described as being optional, and the vowel qualities that are affected. (See the later sections of this chapter for definitions of segmental and prosodic restrictions, which make reference to components of my typological model.) The last three appendices (C-E) provide more detailed information specific to the three typological categories of vowel devoicing that are identified in this chapter.

In order to give a cross-linguistic view of the nature and properties of vowel devoicing processes, I provide data from a variety of languages throughout this dissertation, all of which are included in the VD Database. It will be observed, however, that examples from Cheyenne appear somewhat more frequently and tend to include more in-depth discussion than examples from other languages. This is because Cheyenne exhibits three distinct vowel devoicing processes that happen to correspond to the three different categories of VD identified in the typology, providing an opportunity to illustrate how the segmental and prosodic parameters of vowel devoicing can operate in several different ways within a single language. Additionally, several of the processes provide key pieces of evidence for larger theoretical issues addressed in this dissertation, such as the laryngeal representations of devoiced vowels and the role of domain generalization in vowel devoicing, making Cheyenne an ideal case study for exploring these bigger questions.

3.2 Typogical model of vowel devoicing

This section presents the typological model of vowel devoicing. In this model, segmental and prosodic conditioning factors operate as two separate but interacting parameters. I start by introducing one parameter at a time in 3.2.1 and 3.2.2. I then demonstrate in 3.2.3 how the two parameters may be integrated to form a two-way classification system of vowel devoicing processes. As will be seen, this system identifies three categories of processes attested in the VD Database: (i) (purely) segmentally restricted, (ii) (purely) prosodically restricted, and (iii) prosodically and segmentally restricted. These categories also provide the basis of the formal analysis of vowel devoicing developed in subsequent chapters.

Crucially, this typological model focuses on the broad types of structures (segmental vs. prosodic) that determine the application of vowel devoicing. To this end, it is independent of details concerning the specific segmental and prosodic content involved, for example, the particular types of adjacent consonants that condition a VD process or the particular prosodic boundaries to which a VD process is restricted. The final section of this chapter will provide a closer look at some of these details, since they do inform other theoretical issues to be addressed later in this dissertation, but it is important to note that these details do not bear on the classification system itself.

3.2.1 Segmental parameter

On the segmental dimension, I distinguish between two categories of vowel devoicing, which I refer to as *Segmentally Restricted* and *Segmentally Non-Restricted Vowel Devoicing*. Processes in the former category apply only to vowels adjacent to certain sets of consonants with specific laryngeal properties, in particular voiceless and/or aspirated consonants. Processes in the latter category occur independently of such restrictions on the segmental environment.

Examination of the full set of processes in the VD Database reveals that vowel devoicing in both of these categories is well-attested. Segmentally Restricted VD, however, is more than twice as common as Segmentally Non-Restricted VD, accounting for 68.6% of the processes in the Database. Table 3.2 shows the number of processes in each category, along with the corresponding percentage of the total processes in the Database. Table 3.3 lists the languages in the VD Database that exhibit vowel devoicing processes in each category. Since a single language may contain multiple distinct vowel devoicing processes, a language is listed in both cells if it exhibits processes in both categories. If, on the other hand, a language exhibits several independent processes within a single VD category, it appears only once in the relevant cell, with the number of processes it contributes to that category provided in parentheses.

Segmentally Restricted VD		**Segmentally Non-Restricted VD**	
number	percent	number	percent
48	68.6%	22	31.4%

Table 3.2: Distribution of vowel devoicing processes across the segmental parameter of the typology.

Segmentally Restricted VD	Segmentally Non-Restricted VD
Acoma (2), Ainu, Andean Spanish (2), Ashéninka, Big Smoky Valley Shoshone, Brazilian Portuguese, Cayuga, Cheyenne (2), Chickasaw, Cochabambino Spanish, Comanche, Ecuadorian Spanish (2), European French, Fox, Gangou, Greek, Hrusso Aka, Japanese (2), Korean, Lezgian, Mangghuer, Miami-Illinois, Mokilese, Montreal French, Niuafo'ou (3), Northeast Cree, Northern Paiute (2), Rapa Nui, Salar, Santa, Shipibo, Southern Paiute, Southern Ute, Tohono O'odham, Tongan (2), Tümpisa Shoshone, Turkish, Uyghur, Zihuateutla Totonac	Acoma, Big Smoky Valley Shoshone, Blackfoot, Borana Oromo, Chama, Cheyenne, Comanche, European French, Fox, Ik, Iquito, Malagasy, Nyuangumarta, Oneida, Orma, Pisaflores Tepehua, Southern Paiute, Tohono O'odham, Tümpisa Shoshone, Turkana, Wallaga Oromo, Woleaian

Table 3.3: Languages in the Vowel Devoicing Database according to where their processes fit across the segmental parameter of the typology (see Appendix A for references on each language).

The rest of this subsection discusses the segmental parameter of the vowel devoicing typology in greater detail, illustrated with case studies from the VD Database.

Segmentally Restricted Vowel Devoicing

Segmentally Restricted Vowel Devoicing includes i) processes that require a voiceless or aspirated consonant to the left of the vowel (14 in Database), ii) processes that require a voiceless or aspirated consonant to the right of the vowel (11 in Database), and iii) processes that require voiceless or aspirated consonants on both sides of the vowel (12 in Database). (For the remaining segmentally restricted processes in the

Database, vowels can devoice with a voiceless or aspirated consonant on either side of the vowel, or the position of the segmental trigger is unclear from the sources consulted.) Examples of each of these three main options are seen in (4)–(7). In these examples, and in the data provided in the rest of this dissertation, bold font is used to mark the devoiced vowels in question, and in some cases to mark voiced vowels, when explicit reference is made to them in the text.[2]

Variety (i) of Segmentally Restricted VD, i.e. vowel devoicing conditioned by a consonant to the left of the vowel, is observed in Niuafo'ou (Malayo-Polynesian), which exhibits several distinct VD processes. This language will be discussed in more detail in Chapter 5. The process of relevance here devoices high vowels after voiceless fricatives, as shown in (4). Note that vowel devoicing never occurs in hiatus in Niuafo'ou, so the vowel after the second [f] does not devoice in example (4a). The environment to the right of the vowel does not otherwise matter, since, as can be seen in these examples, VD occurs before different types of consonants as well as before a word boundary, as long as the consonant to the left of the vowel is a voiceless fricative.

(4) Segmentally Restricted VD in Niuafo'ou after voiceless fricatives (Tsukamoto 1988)

a. [ˌmof**u̥**ˌmof**u**ˈiˑke] 'have earthquakes repeatedly'

b. [ˌkis**u̥**ˈheː] interjection

c. [ˌmos**i̥**ˈmoˑs**i̥**] 'light rain'

[2] I make reference to many different linguistic sources in the examples in this dissertation, which use a variety of transcription systems. For consistency across languages and sources, I convert all transcriptions to standard IPA notation based on the descriptions presented in each source. For the present purposes, the most important conventions I assume are the marking of primary stress, secondary stress, and devoicing as shown on [a] here: [ˈa], [ˌa], [ḁ].

An example of variety (ii) can be seen in Comanche (Uto-Aztecan), where short vowels of any quality devoice before /s/ and /h/. This process is shown in (5) and will be discussed in a more detailed case study in Chapter 4.

(5) Segmentally Restricted VD in Comanche before /s/ and /h/ (Robinson & Armagost 2012)

a. [kup**i̥**simawa] 'croton weed'

b. [wanaʔ**ɯ̥**hu] 'cloth blanket'

Cheyenne (Algonquian), like Niuafo'ou, exhibits several distinct vowel devoicing processes, which will be discussed in greater detail in Chapters 4 and 5. One of these processes provides an additional example of variety (ii), targeting low tone vowels before voiceless fricatives, as shown in (6). Note that the acute accent indicates high tone.

(6) Segmentally Restricted VD in Cheyenne before voiceless fricatives (Leman 1980)

a. [nam**e̥**ʃeme] 'grandfather'

b. [m**o̥**xéheoʔo] 'broom'

Finally, an example of variety (iii) of Segmentally Restricted VD is the well-known process of Japanese High Vowel Devoicing, which requires a voiceless consonant on both sides of the vowel. Note that the full range of VD phenomena in Japanese is complex, and the descriptions in the literature vary by dialect and, to some extent, by the phonetic or phonological perspective taken by different researchers. For the present purposes, I focus here on the classic case of vowel devoicing between two voiceless consonants, shown in (7) below. Minimal pairs for these examples, in parentheses, demonstrate that a voiceless consonant on only one side of the vowel is not sufficient for devoicing. This is in contrast to the previous three VD processes discussed in this section, which exhibit segmental restrictions on only one side of the vowel.

(7) Segmentally Restricted VD in Japanese between two voiceless consonants (Tsuchida 1997)

a. [k**i̥**too] 'prayer' (vs. [k**i**doo] 'orbit')

b. [φ**u̥**ka] 'incubation' (vs. [b**u**ka] 'subordinate')

While these examples demonstrate that the details of Segmentally Restricted VD differ somewhat from process to process, the crucial similarity among all of the processes in this category is that vowels only devoice adjacent to consonants with a relatively open glottis, a property associated with phonological voicelessness or aspiration. It is precisely this property that vowels take on when they devoice via Segmentally Restricted VD. Thus, from a phonological perspective, Segmentally Restricted Vowel Devoicing can be understood as a form of laryngeal assimilation, assumed here to be feature spreading, between a consonant and adjacent vowel.

It is also important to note that while laryngeal assimilation in Segmentally Restricted VD can go in either direction, it rarely extends beyond one segment to the left or right of the triggering consonant. That is, unlike some other processes of assimilation or feature spreading that can extend longer distances, such as nasal harmony and other harmony phenomena (e.g., Rose & Walker 2011), vowel devoicing is generally a local process affecting only one vowel at a time.

Segmentally Non-Restricted Vowel Devoicing

Segmentally Non-Restricted Vowel Devoicing affects vowels with and without adjacent voiceless or aspirated consonants. For example, in the Wallaga variety of Oromo (Cushitic), word-final vowels devoice regardless of the segmental environment to their left. This can be seen in (8). The examples in (8a) and (8b) show devoicing after a voiceless consonant and a voiced consonant, respectively. (8c) shows devoicing after another vowel. Note, however, that VD in vowel hiatus is quite rare overall in the VD Database.

(8) Segmentally Non-Restricted VD in Wallaga Oromo (Dissassa 1980)

a. [ˈkɛsḁ] 'in'

b. [ˈkɛɲḁ] 'ours'

c. [namboḁ] 'I cry'[3]

Similarly, Cheyenne exhibits Segmentally Non-Restricted VD phrase-finally, regardless of the preceding consonant. That is, while throughout a word, vowels typically devoice only before voiceless fricatives in Cheyenne (as shown in (6)), phrase-final vowels may devoice in any segmental environment. Cheyenne Segmentally Non-Restricted VD is shown in (9a) and (9b) after a voiceless consonant and after a voiced consonant, respectively.[4]

[3]The source does not provide stress in this example, so it is not marked here.

[4]It should be noted that Leman 2011 has suggested that voiced onsets followed by devoiced vowels are also prone to devoicing in Cheyenne. I have observed, however, that these onsets still exhibit a voicing bar, but with relatively low intensity. I take this to reflect a phonetic effect of coarticulation between a voiced onset and devoiced vowel rather than phonological devoicing of voiced onsets.

(9) Segmentally Non-Restricted VD in Cheyenne (Fisher, Leman, Pine, & Sanchez 2017)[5]

a. [hotóakósḁ] 'ram'

b. [návóomḁ] 'he saw me'

Crucially, the Wallaga Oromo and Cheyenne cases demonstrate that Segmentally Non-Restricted VD cannot be attributed to laryngeal assimilation or feature spreading the way Segmentally Restricted VD can. That is, in these cases, vowels may devoice in the absence of an adjacent consonant bearing either a [+spread glottis] or a [-voice] feature. Thus, the voicelessness in these processes must arise via a fundamentally different source. The source of voicelessness for this category of VD will be addressed in detail in Chapters 4 and 5.

3.2.2 Prosodic parameter

On the prosodic dimension of the typology, I also distinguish between two main categories of processes determined by whether or not their distributions are constrained in crucial ways. That is, vowel devoicing may be either *Prosodically Restricted* or *Prosodically Non-Restricted*. As with the categories defined by the segmental parameter, both categories on the prosodic dimension are well-attested within the VD Database, and in this case, comprise equal numbers of processes. Table 3.4 shows the total number of processes in each prosodic category along with the corresponding percentage of total processes in the VD Database. Table 3.5 lists the languages in the Database that exhibit processes in each category. As in Table 3.3 in the previous subsection, when one language exhibits multiple processes that

[5] I transcribed the vowel devoicing in these examples myself from the audio recordings in Fisher et al. (2017)'s online dictionary.

are classified differently along the prosodic dimension of the typology, it is listed once in each cell. When a single language exhibits multiple processes in the same prosodic category, it is listed once in the relevant cell with the total number of processes it contains in that category provided in parentheses.

Prosodically Restricted VD		**Prosodically Non-Restricted VD**	
number	percent	number	percent
35	50%	35	50%

Table 3.4: Distribution of vowel devoicing processes across the prosodic parameter of the typology.

Prosodically Restricted VD	**Prosodically Non-Restricted VD**
Acoma (2), Andean Spanish, Big Smoky Valley Shoshone, Blackfoot, Borana Oromo, Brazilian Portuguese, Chama, Cheyenne (2), Chickasaw, Comanche, Ecuadorian Spanish (2), European French, Fox, Ik, Iquito, Japanese, Lezgian, Malagasy, Northern Paiute, Nyangumarta, Oneida, Orma, Pisaflores Tepehua, Rapa Nui, Santa, Southern Paiute, Tohono O'odham, Tümpisa Shoshone, Turkana, Wallaga Oromo, Woleaian, Zihuateutla Totonac	Acoma, Ainu, Andean Spanish, Ashéninka, Big Smoky Valley Shoshone, Cayuga, Cheyenne, Cochabambino Spanish, European French, Fox, Gangou, Greek, Hrusso Aka, Japanese, Korean, Mangguer, Miami-Illinois, Mokilese, Montreal French, Niuafo'ou (3), Northeast Cree, Northern Paiute, Salar, Shipibo, Southern Paiute, Southern Ute, Tohono O'odham, Tongan (2), Tümpisa Shoshone, Turkish, Uyghur

Table 3.5: Languages in the Vowel Devoicing Database according to where their processes fit across the prosodic parameter of the typology (see Appendix A for references on each language).

The rest of this subsection discusses the prosodic parameter of the vowel devoicing typology in greater detail, illustrated with case studies from the VD Database.

Prosodically Restricted Vowel Devoicing

I use Prosodically Restricted VD to refer to processes that occur in only one structural position within a prosodic domain. This position is typically the right edge of a domain, as is the case for the Wallaga Oromo and Cheyenne domain-final processes previously seen in Section 3.2.1, where they were presented to illustrate Segmentally Non-Restricted VD. The prosodic restrictions on these processes are illustrated in greater detail here.[6]

Recall from the previous discussion that vowels in Wallaga Oromo devoice in any segmental environment as long as they are in a word-final position. The word-final restriction on this process can be seen more explicitly in the additional data provided below in (10a) and (10b). These examples compare the same unstressed syllable *ra* in word-final and medial positions. The vowel devoices only in the former, where the prosodic restriction is met. Note that, as expected, the word-final vowel in (10b) also devoices.

(10) Prosodically Restricted VD in Wallaga Oromo word-final vowels (Dissassa 1980)

a. [ˈnarḁ] ‘brow’

b. [wəraˈbesḁ] ‘hyena’

Similarly, Cheyenne vowels devoice in any segmental environment as long as they are phrase-final. The additional Cheyenne examples in (11) show the word *névóohtáhe* in two different phrasal positions. In (11a), the word-final vowel of

[6]While Prosodically Restricted VD can occur in a wider range of environments, word- and phrase-final vowel devoicing in particular may be seen to resemble the well-known phenomenon of domain-final obstruent devoicing. As noted in Section 1.2 of this dissertation, however, the two different types of devoicing require crucially different phonological anlayses.

névóohtáhe is at the end of the phrase and thus undergoes devoicing. In (11b), on the other hand, the same vowel is in a phrase-medial position and does not devoice, demonstrating that it is the position within the phrase, rather than segmental environment (or position within the word), that is relevant for this process. Note that in (11b), the final vowel of the second word does devoice as predicted.

(11) Prosodically restricted devoicing in Cheyenne phrase-final vowels (Leman & Rhodes 1978)

   a. [névóohtáhe̥] 'do you see it?'

   b. [névóohtáh**e** mahpe̥] 'Do you see the water?'

There are also several cases in which VD is restricted to another structural prosodic position, such as directly preceding the stressed syllable, which may be analyzed as the non-head syllable of a foot (e.g., in Lezgian, Chitoran & Babaliyeva 2007; Chitoran & Iskarous 2008, and in Ecuadorian Spanish, Lipski 1990).[7]

Prosodically Non-Restricted Vowel Devoicing

Prosodically Non-Restricted VD refers to processes that can occur across an entire prosodic domain, along the lines of domain span rules discussed in early prosodic phonology literature (Selkirk 1980; I. Vogel 1984). One such example is the Cheyenne process of vowel devoicing before voiceless fricatives, which was previously seen in the context of Segmentally Restricted VD in Section 3.2.1. This phenomenon may occur in almost any position in the word, including in consecutive syllables, as shown in (12) below, where the vowels in the first three syllables are all devoiced by

[7]Unfortunately, there is also very limited data for the few processes restricted to other types of prosodic positions, so additional data and further analysis of these cases would be needed in order to evaluate them more thoroughly.

the same process. Note that the penultimate vowel in this example, which devoices before an affricate, is affected by a third vowel devoicing process, which will be discussed in greater detail in Chapter 4.

(12) Prosodically Non-Restricted VD in Cheyenne before voiceless fricatives (Leman 1981):
[mḁhno̥htse̥stovo̥tse] ‘when you ask him’

It was previously pointed out in relation to the segmental parameter that the proposed typology leaves room for variation in certain language-specific details, across which the same major generalizations hold. This is true with regard to the prosodic parameter as well, concerning for instance the particular domain or position to which a process is restricted. In fact, it was just seen above that Prosodically Restricted VD requires reference to the edge of a word in Wallaga Oromo, but to the edge of a larger domain (i.e. phrase) in Cheyenne. In other cases, the application of VD may be limited to the end of an utterance or to the pretonic syllable. The crucial generalization here is that for all Prosodically Restricted VD processes, their application is limited to one specific position in the relevant domain defined in terms of a major aspect of prosodic structure. The application of Prosodically Non-Restricted VD, in contrast, is not limited in such a way.

3.2.3 Integration of the two parameters

This chapter has thus far considered the distribution of vowel devoicing processes in the VD Database in relation to the segmental and prosodic parameters independently. For both parameters, I proposed a distinction between processes that are restricted to a single environment defined in terms of the relevant parameter and those that are not restricted in such a way. While processes with and without each type of restriction are well-attested, it was seen that the processes are distributed differently across the two parameters. That is, over two thirds of processes in the Database involve a segmental restriction, whereas there is a roughly even split between prosodically restricted and prosodically non-restricted processes. Crucially, this means that the relationship between these two parameters is not a simple trade off, wherein all segmentally restricted processes (i.e. a little over two thirds of the Database) are prosodically non-restricted, and all segmentally non-restricted processes (i.e. slightly less than one third of the Database) are prosodically restricted. Rather, while some processes are conditioned only by a single parameter, there are others conditioned by an interaction of the two parameters It is therefore essential to consider not only each parameter individually, but also how the two relate to each other.

In principle, the restricted and non-restricted categories defined in terms of each parameter outlined in this chapter could combine in four ways, resulting in four possible types of vowel devoicing: (i) Segmentally Restricted (but prosodically non-restricted) VD, (ii) Prosodically Restricted (but segmentally non-restricted) VD, (iii) Prosodically and Segmentally Restricted VD, meaning that devoicing can only occur adjacent to a voiceless/aspirated consonant in one specific prosodic position, and (iv) Prosodically and Segmentally Non-Restricted VD, meaning that devoicing can occur in any environment. These four potential categories, along with the distribution of VD processes across them, are presented in Tables 3.6 and 3.7 below. The first table shows the numbers and corresponding percentages of processes in the VD Database that fall in each category. The second lists the languages in the Database that exhibit each type of process.

	Segmentally Restricted		**Segmentally Non-Restricted**	
	number	percent	number	percent
Prosodically Restricted	13	18.6%	22	31.4%
Prosodically Non-Restricted	35	50%	0	0%

Table 3.6: Four predicted types of vowel devoicing and their distribution in the Database.

	Segmentally Restricted	**Segmentally Non-Restricted**
Prosodically Restricted	Acoma, Andean Spanish, Borana Oromo, Brazilian Portuguese, Cheyenne, Chickasaw, Ecuadorian Spanish, Japanese, Lezgian, Northern Paiute, Rapa Nui, Santa, Zihuateutla Totonac	Acoma, Big Smoky Valley Shoshone, Blackfoot, Chama, Cheyenne, Comanche, European French, Fox, Ik, Iquito, Tümpisa Shoshone, Malagasy, Nyangumarta, Oneida, Orma, Pisaflores Tepehua, Sandawe, Southern Paiute, Tohono O'odham, Turkana, Wallaga Oromo, Woleaian
Prosodically Non-Restricted	Acoma, Ainu, Andean Spanish, Ashéninka, Big Smoky Valley Shoshone, Cayuga, Cheyenne, Cochabambino Spanish, Comanche, European French, Fox, Gangou, Greek, Hrusso Aka, Japanese, Korean, Mangghuer, Miami-Illinois, Mokilese, Montreal French, Niuafo'ou (3), Northeast Cree, Northern Paiute, Salar, Shipibo, Southern Paiute, Southern Ute, Tohono O'odham, Tongan (2), Turkish, Uyghur, Tümpisa Shoshone	n/a

Table 3.7: Four predicted types of vowel devoicing and languages from the Database in each (see Appendix A for references on each language).

It can be seen from these tables that three of the four logically possible types of vowel devoicing are well-attested in the VD Database. The fourth category, in which there are neither prosodic nor segmental restrictions, is not attested, and in fact, by definition should not exist. That is, since voiceless vowels are always allophonic, as noted in Chapter 2, their distribution must be predictable, and thus conditioned by some phonological factor or factors (i.e. segmental and/or prosodic environment). If voiceless vowels occurred in completely non-restricted positions, they would be in contrastive distribution with voiced vowels instead, in other words, phonemic rather than allophonic. The apparent gap in the typology is therefore exactly what should be expected.

The first two attested types of VD, (purely) Segmentally Restricted VD and (purely) Prosodically Restricted VD, have already been illustrated with examples from Niuafo'ou, Comanche, Cheyenne, Japanese, and Wallaga Oromo in 3.2.1 and 3.2.2. The third attested type of VD will be illustrated below with a process from Northern Paiute.

Prosodically and Segmentally Restricted Vowel Devoicing

In Northern Paiute (Uto-Aztecan), unstressed word-final vowels optionally devoice after obstruents, which are voiceless in that environment, but not after (voiced) sonorants.[8] While there are some additional considerations regarding the overall VD pattern in this language, the crucial cases for illustrating the prosodically and segmentally restricted category of vowel devoicing are seen in (13). The word in (13a) shows the same unstressed syllable *pi* in word-initial and word-final environments. The /i/ devoices only in the word-final syllable, reflecting the prosodic restriction on the process. A comparison of (13a) and (13b) shows that while word-final /i/

[8]The literature on Northern Paiute (Louie 2010; Thornes 2003) suggests that there is a set of preaspirated or voiceless sonorants, after which I would predict devoicing could occur; however, these sources do not provide the necessary information to test this.

devoices after a voiceless stop, it does not devoice after a nasal, reflecting the segmental restriction on the process.

(13) Prosodically and Segmentally Restricted VD in Northern Paiute (Thornes 2003)

a. [p**i**ˈdzap**i̥**] ‘want; like’

b. [kuˈan**i**] ‘to cook (transitive)’

Thus, in order to account for Northern Paiute VD, we need a combination of restrictions limiting the application of this process to a specific prosodic position and, within that structural position, to a specific segmental position. When the condition for only one parameter is met, devoicing cannot occur. It should also be noted that while the segmental restriction in Northern Paiute makes reference to the left side of the vowel, the larger category of Prosodically and Segmentally Restricted VD includes processes with segmental restrictions to the right side of the vowel as well. For instance, as will be seen in a case study in Chapter 4, Cheyenne exhibits a process in this category that is restricted to vowels in the underlying word-final syllable with voiceless obstruents to their right.

3.3 Additional patterns within each typological category

As noted in the previous section, the typological model advanced in this chapter focuses on the roles of and interactions between two broad parameters in vowel devoicing: segmental and prosodic restrictions. These parameters moreover leave room for variation in the specific types of segmental material and prosodic structures to which individual processes are restricted. In this way, the model allows for variation in language-specific details to be accounted for with the same underlying mechanisms, as will be seen in the formal phonological analysis of vowel devoicing presented in subsequent chapters.

At the same time, some patterns of variation within the three broad categories of VD can provide different types of insights into larger theoretical issues in phonology and can inform the formal analysis in specific ways. This section presents three such patterns. First, 3.3.1 addresses the specific types of consonants involved in Segmentally Restricted VD. Then, 3.3.2 provides a closer look at the different prosodic domains at which the two prosodically restricted categories of VD take place. Finally, 3.3.3 discusses the roles of stress and high tone in vowel devoicing across the VD Database.

3.3.1 Consonants involved in Segmentally Restricted Vowel Devoicing

As indicated in 3.2.1, not only does the direction of laryngeal assimilation vary across segmentally restricted VD processes, but so do the sets of voiceless and/or aspirated consonants that trigger these processes. This subsection provides a closer look at the sets of consonants that trigger Segmentally Restricted VD cross-linguistically. I include both (purely) Segmentally Restricted VD and Prosodically and Segmentally Restricted VD here.

Table 3.8 lists the sets of consonants found to trigger VD in the Database, as well as the number of processes triggered by each set. Table 3.9 lists the languages exhibiting processes triggered by each set of consonants.

Consonantal triggers	# of processes
a. All voiceless consonants	30
b. Voiceless fricatives	8
c. /h/ or preaspirated stops	4
d. Aspirated stops and affricates, voiceless fricatives	1
e. Different requirements on left vs. right	3
f. Unclear	2

Table 3.8: Consonants triggering Segmentally Restricted VD.

Consonantal triggers	# of processes
a. All voiceless consonants	Acoma, Ainu, Andean Spanish (2), Brazilian Portuguese, Cheyenne, Chickasaw, Cochabambino Spanish, European French, Greek, Hrusso Aka, Japanese (2), Korean, Lezgian, Mangguer, Mokilese, Montreal French, Niuafo'ou, Northeast Cree, Northern Paiute, Rapa Nui, Salar, Southern Paiute, Southern Ute, Tongan, Tümpisa Shoshone, Turkish, Uyghur, Zihuateutla Totonac
b. Voiceless fricatives	Acoma, Cheyenne, Comanche, Ecuadorian Spanish (2), Fox, Niuafo'ou, Northern Paiute
c. /h/ or preaspirated stops	Big Smoky Valley Shoshone, Cayuga, Miami-Illinois, Niuafo'ou
d. Aspirated stops and affricates, voiceless fricatives	Gangou
e. Different requirements on left vs. right	Santa, Shipibo, Tongan
f. Unclear	Ashéninka, Tohono O'odham

Table 3.9: Consonants triggering Segmentally Restricted VD.

The first four rows of these tables include processes triggered by one consistent set of consonants. The second to last row includes the three processes that exhibit different requirements on each side of the vowel, and the last row includes the two processes for which the precise segmental triggers cannot be confidently determined from the sources consulted.

It should be noted that while the three processes with different conditioning requirements on each side of the vowel are a bit more complex, the individual requirements conform to the categories identified in the first five rows. For instance, in Santa (Kim 2003), the consonant to the left of the vowel can be any voiceless consonant, and the consonant to the right of the vowel must be either an aspirated consonant or a voiceless fricative. Thus, the segmental restriction to the left of the vowel in Santa resembles the environments of processes in row (a) of the table, whereas the segmental restriction to the right resembles row (d) of the table. Similarly, in Tongan (Feldman 1978), VD occurs in vowels preceded by /h/, like the processes in row (c), and followed by any voiceless consonant, like the processes in row (a).

While Tables 3.8 and 3.9 show that any voiceless or aspirated consonant can trigger Segmentally Restricted Vowel Devoicing, some important restrictions exist with regard to the specific classes of voiceless consonants that do and do not pattern together. In particular, we see that voiceless fricatives can pattern i) with all other voiceless consonants, ii) with aspirated stops and affricates, or iii) on their own to trigger vowel devoicing. (Unaspirated) voiceless stops, on the other hand, never pattern alone; rather, they only trigger vowel devoicing as part of a larger set including all voiceless consonants. Thus, we have an implicational relationship between unaspirated voiceless stops and other consonantal triggers, such that vowel devoicing adjacent to voiceless stops implies vowel devoicing adjacent to other voiceless consonants (see row (a) of the table). In contrast, vowel devoicing adjacent to voiceless friatives does not imply vowel devoicing adjacent to voiceless stops - or adjacent to other types of consonants (see row (b) of the table). As will be seen in Chapter 5, the implicational relationship between voiceless stops and voiceless fricatives provides important evidence concerning the laryngeal features needed to account for vowel devoicing cross-linguistically.

3.3.2 Prosodic domains in Prosodically Restricted Vowel Devoicing

Turning to variation within Prosodically Restricted VD, it was noted in 3.2.2 that these processes can be triggered by different types of prosodic positions. As also noted in that section, the vast majority of prosodically restricted processes occur in domain-final positions. In fact, domain-final processes constitute 30 of the 35 processes in this larger category. I therefore focus here on domain-final processes, since they provide adequate data for robust patterns to emerge.

Table 3.10 shows the distribution of domain-final VD processes in the Database across different sized domains.[9] In this table, and in the rest of this dissertation, I refer to phrase- and utterance-final processes collectively as "large domain-final," since it is not possible to characterize these domains more precisely or consistently based on the existing sources. In most cases, especially in older studies, finer-grained distinctions were not explicitly discussed. When more specific domains are referenced, they tend to reflect the theoretical assumptions of individual researchers. More generally, the consistent identification of larger prosodic domains would require comparable, systematic data regarding the interface between the phonological and syntactic structures across all of the languages. In fact, as will be seen later in this section, finer-grained distinctions among the larger constituents turn out not to be necessary. That is, all but one of the processes (Zihuateutla Totonac VD) that are restricted to domains above the word pattern in the same way with respect to the issues examined here. Thus, additional distinctions, even if possible, would not contribute further to the present analysis.

[9]Note that one domain-final process from Big Smoky Valley Shoshone is excluded from the table because it was not possible to determine whether it is word-final or large domain-final from available descriptions. Thus, the total number of processes in this table is 29 rather than 30.

Word-final VD		Large domain-final VD	
number	percent	number	percent
14	24.1%	15	75.9%

Table 3.10: Counts and percentages of word vs. large domain-final vowel devoicing.

As can be seen in Table 3.10, word-final vowel devoicing and large domain-final vowel devoicing are essentially equally common. Interestingly, however, the role of segmental restrictions is not distributed evenly across the different sized domains. This is shown in Table 3.11, which further distinguishes the processes according to whether they are both prosodically and segmentally restricted or only prosodically restricted. Table 3.12 lists the languages exhibiting each of these types of processes.

	Word-final		**Large domain-final**	
	number	percent	number	percent
Segmentally Restricted	7	50%	1	6.7%
Segmentally Non-Restricted	7	50%	14	93.3%

Table 3.11: Counts and percentages of segmentally restricted vs. segmentally non-restricted domain-final devoicing by prosodic domain.

	Word-final	**Large domain-final**
Segmentally Restricted	Andean Spanish, Brazilian Portuguese, Cheyenne, Ecuadorian Spanish, Japanese, Northern Paiute, Rapa Nui	Zihuateutla Totonac
Segmentally Non-Restricted	Acoma, Borana Oromo, Orma, Southern Paiute, Tohono O'odham, Wallaga Oromo, Woleaian	Blackfoot, Chama, Cheyenne, Comanche, European French, Fox, Ik, Iquito, Tümpisa Shoshone, Malagasy, Nyangumarta, Oneida, Pisaflores Tepehua, Turkana

Table 3.12: Languages with segmentally restricted vs. segmentally non-restricted domain-final devoicing by prosodic domain.

Within the word-final category, we see that (purely) Prosodically Restricted VD and Prosodically and Segmentally Restricted VD are equally common. In the large domain-final category, on the other hand, all but one of the processes are (purely) prosodically restricted. The implications of this pattern will be addressed in Chapter 5.

3.3.3 Other interactions between prosody and vowel devoicing

Finally, we may consider several additional aspects of prosody, which play a role in the application of vowel devoicing but which are orthogonal to the typological split between prosodically restricted and non-restricted processes. First, as discussed in Chapter 2, in languages that exhibit stress, stressed vowels are known to resist or block devoicing (e.g., Gordon 1998; Greenberg 1969). The VD Database shows this to be the case even for processes that otherwise apply across an entire prosodic domain. In fact, of the 29 prosodically non-restricted VD processes that occur in languages with stress or other abstract word-level prominence, 28 are said to be blocked by stress or prominence. (For the 29th process, which occurs in Tümpisa Shoshone, interactions with stress are not mentioned, but there is no evidence that stressed vowels can actually devoice.)

With prosodically restricted processes, it is not always possible to observe the effect of stress on vowel devoicing, since in a number of languages, stress never falls in the position to which VD is restricted. For instance, in Iquito, short vowels devoice in word-final position, but stress never occurs on word-final short vowels. Similarly, in Lezgian, vowels in the immediately pretonic syllable devoice, but this syllable, by definition, is never stressed. In 13 languages with domain-final VD, however, stress can fall in word-final position. In all of these cases, stress indeed blocks VD.

Earlier studies also noted that high tone vowels devoice less frequently than low tone vowels cross-linguistically (Gordon 1998; Greenberg 1969). Again, the VD Database showed similar patterns for both prosodically restricted and prosodically non-restricted processes. Of the five prosodically non-restricted processes that are definitively described as having tone, three are blocked by high tone. (These are found in Acoma, Cheyenne, Japanese.) In one of the remaining two languages (Shipibo), tone interacts with stress in such a way that high tone only appears in stressed syllables, so the effect of tone is not distinguishable from the effect of stress. In the last language (Gangou), interactions with tone are not mentioned. There are also 10 prosodically restricted processes definitively described as having tone. Of these, three are blocked by high tone (processes in Acoma, Borana Oromo, Orma). Crucially, no language exhibits a similar effect with low tone. Thus, as originally noted by Greenberg, the presence of high tone vowel devoicing implies the presence of low tone vowel devoicing, but not vice versa.

Cheyenne is one of the languages in which both abstract word-level prosodic prominence and high tone block vowel devoicing. The word [ék**á**so̥xeʔ**o**he] 'it is written short' (Fisher et al. 2017) illustrates both of these effects. The bolded vowels in the second, third, and penultimate syllables are all in appropriate segmental environments for the (purely) segmentally restricted vowel devoicing process before voiceless fricatives. Nevertheless, the /a/ in the second syllable does not devoice because it has a high tone, and the /o/ in the penultimate syllable does not devoice because it is in a structurally prominent position, analyzed as an abstract prosodic head (Bogomolets 2019; Milliken 1983; R. Vogel 2021), and thus may be considered analogous to stress.

The effect of stress, as a structural prosodic property, is particularly relevant for our understanding of the relationship between prosodic structure and segmental phonology. I will therefore return to it in subsequent chapters, where it will inform the formal analysis of vowel devoicing. Since the same basic relationship between stress and vowel devoicing holds in all languages that exhibit stress, however, this effect must be somewhat independent from the effects of other prosodic positions like domain-final and immediately pretonic syllables, since the latter play a role only in specific subsets of VD processes and therefore reflect major distinctions between different categories of processes in the typological model. Both types of effects will be accounted for in Chapters 4 and 5.

3.4 Discussion

This chapter has presented a typological model of vowel devoicing in which prosodic and segmental conditioning factors operate as two separate but interacting parameters in conditioning VD processes cross-linguistically. These parameters can combine in different ways to produce three attested categories of processes: (purely) Segmentally Restricted Vowel Devoicing, (purely) Prosodically Restricted Vowel Devoicing, and Prosodically and Segmentally Restricted Vowel Devoicing. This approach has yielded two crucial insights that could not be obtained if the two parameters were simply viewed in isolation. First, we see that some processes are conditioned only by segmental environment and others only by prosodic structure. Thus, any attempt to reduce all VD phenomena to a single mechanism cannot be maintained. Rather, in order for a model of vowel devoicing to accurately and appropriately account for its distribution cross-linguistically, it must include distinct prosodic and segmental mechanisms. At the same time, however, it is clear that a non-trivial percentage (18.6%) of the processes in the VD Database require some interaction between prosodic and segmental conditioning factors (i.e. Prosodically and Segmentally Restricted VD). We must, therefore, also allow for an apparent interaction between the two mechanisms.

This chapter also explored several more detailed patterns within the broad typological categories. Specifically, these were the sets of consonants that trigger Segmentally Restricted VD, the distribution of (purely) Prosodically Restricted VD and Prosodically and Segmentally Restricted VD across different sized prosodic domains, and the roles of stress and high tone in all three types of VD.

The next chapter (Chapter 4) presents a formal phonological analysis of vowel devoicing in Optimality Theory based on the typology. This analysis both differentiates between the three broad categories of vowel devoicing according to which parameter or parameters are involved, and also offers a means of accounting for language-specific details that may arise within each category. The following chapter (Chapter 5) then considers the larger theoretical implications of the cross-linguistic findings presented in the present chapter as well as further insights obtained by the Optimality Theoretic analysis.

CHAPTER 4

FORMAL ANALYSIS OF CROSS-LINGUISTIC PATTERNS OF VOWEL DEVOICING

This chapter provides a constraint-based analysis of vowel devoicing within Optimality Theory based on the findings of the cross-linguistic survey and typological model of VD developed in Chapter 3. Crucially, it was shown that prosodic and segmental factors operate as two separate, but interacting, parameters conditioning the range of vowel devoicing phenomena observed in the VD Database. These parameters and their interaction produce three categories of vowel devoicing: i) Segmentally Restricted (and prosodically non-restricted) VD, ii) Prosodically Restricted (and segmentally non-restricted) VD, and iii) Prosodically and Segmentally Restricted VD.

It will be recalled that a crucial aspect of VD is that voicelessness in vowels is always predictable (i.e. allophonic). Voiceless vowels therefore do not constitute contrastive segments. Within Optimality Theory, this means that their distribution in surface forms must be governed largely by markedness constraints. More specifically, it will be seen that the presence and distribution of voiceless vowels arise from interactions between a general constraint prohibiting voiceless vowels, and other constraints requiring them in specific segmental or prosodic environments.

In this chapter, I first introduce the formal means of accounting for the two basic mechanisms of vowel devoicing (segmental and prosodic) independently, addressing the segmentally restricted processes without prosodic restrictions, followed by the prosodically restricted processes without segmental restrictions. I will refer to these two categories moving forward as (purely) Segmentally Restricted VD and (purely) Prosodically Restricted VD. I then turn to vowel devoicing phenomena that are restricted by both segmental and prosodic parameters, i.e. Prosodically and Segmentally Restricted VD. As will be demonstrated, this type of process is best understood as a variant of the basic prosodically restricted type, which results from a different ranking of the same set of constraints.

Each type of vowel devoicing is illustrated on the basis of one case study: Comanche VD before voiceless fricatives (Section 4.1), Wallaga Oromo VD in word-final position (Section 4.2), and Cheyenne VD before voiceless obstruents, in word-final position (Section 4.3). These case studies exemplify the general, invariable nature of the constraints and constraint interactions that hold for all VD processes in a given category. Additionally, they allow us to identify minor adaptations to the formulation of the constraints that produce the language-specific details and variations within each category observed in the VD Database.

4.1 Formal analysis of (purely) Segmentally Restricted Vowel Devoicing

Recall from Chapter 3 that Segmentally Restricted Vowel Devoicing refers to those processes that affect vowels adjacent to specific sets of consonants. While the particular triggering consonants vary to some extent cross-linguistically, as discussed in 3.3.1, they share the property of being produced with an articulation involving a relatively open glottis (e.g., some set of voiceless and/or aspirated consonants). It is precisely this property that the vowels in question take on when they devoice. Thus, Segmentally Restricted VD may be defined as a process of laryngeal assimilation, involving feature spreading between a voiceless or aspirated consonant and the adjacent vowel. This is straightforwardly accounted for in the analysis proposed here with a markedness constraint that requires a laryngeal feature associated with a consonant to be shared with an adjacent segment.

In this section, I return to the case of Comanche (Uto-Aztecan), introduced previously in Chapter 3, as an illustration of Segmentally Restricted VD before voiceless fricatives, which I analyze as spreading of a [+spread glottis] feature. I first describe the basic pattern of Comanche vowel devoicing and then present the crucial constraint interactions I use to account for it. I also highlight the ways in which the Comanche analysis illustrates the general nature of the constraints involved, and how they may be minimally adapted to account for the particular set of triggering consonants and the larger phonological context of a given language.

4.1.1 Basics of Comanche vowel devoicing

The analysis of Comanche vowel devoicing provided here is based on the data and description in Robinson and Armagost (2012)'s dictionary and grammar of the language. In order to understand the VD process itself, it is necessary to first consider the Comanche phoneme inventory. The consonant and vowel inventories are provided in Tables 4.1 and 4.2, respectively.[1] In cases of discrepancy between the transcriptions in the grammar and IPA representations, the former are converted to standard IPA symbols.

[1]Robinson and Armagost treat /h/ and /H/ as glides in their phoneme inventory; however, /h/ behaves as a voiceless fricative, patterning with /s/ in crucial phonological processes. I have used parentheses around /H/, since there is not enough information in the original source to adequately determine its phonetic and phonological nature, a matter which remains for future research. For the present purposes, I simply continue to group it with /h/ in the chart for convenience.

	Bilabial	**Dental**	**Palatal**	**Velar**	**Rounded Velar**	**Glottal**
Stop	p	t		k	kʷ	ʔ
Affricate		ts				
Fricative		s				h, (H)
Nasal	m	n				
Glide			j		w	

Table 4.1: Comanche consonant inventory (based on Robinson & Armagost 2012)

	Front	**Central**	**Back**
High	i	ɯ	u
Mid	e		o
Low		a	

Table 4.2: Comanche vowel inventory (based on Robinson & Armagost 2012)

As can be seen in Table 4.1, there is no laryngeal contrast in the Comanche consonant system; all obstruents are voiceless and all sonorants are voiced. It is unclear what the abstract segment /H/ represents, since it surfaces as [h] in some environments, but otherwise behaves quite differently from /h/ in phonological processes. For the present purposes, I focus on /s/ and /h/, the two segments in the inventory that are clearly voiceless fricatives and which, crucially, function similarly with respect to triggering vowel devoicing. As can be seen in Table 4.2, there is no vowel length contrast in the language; sequences of two vowels are analyzed as two syllable nuclei. The additional important points to note regarding Comanche vowels are that i) all vowel qualities can devoice, but ii) vowels in hiatus never devoice, the latter point consistent with a nearly universal pattern observed cross-linguistically.

Turning to the vowel devoicing process itself, as discussed in Chapter 3, Segmentally Restricted VD occurs in Comanche before both /s/ and /h/. This is shown in (14) and (15) respectively. The segments to the left of the voiceless vowels in these examples show that devoicing may occur after any type of consonant, including (voiced) sonorants as in example (14a). Note that all of the Comanche examples are derived from Robinson & Armagost 2012. As in Chapter 3, bold is used to mark the segments of interest here and throughout this chapter.

(14) Comanche VD before /s/

a. [omom**ɯ̥**sɯ] ‘on foot’ (with intensifier)

b. [kup**i̥**simawa] ‘croton weed’

(15) Comanche VD before /h/

a. [ek**ḁ**huutsuʔ] ‘cardinal, redbird’

b. [wanaʔ**ɯ̥**hu] ‘cloth blanket’

For a more complete understanding of Comanche VD, it is interesting to note that an independent process deletes /h/ in coda position in Comanche, thus obscuring the conditioning environment of some instances of vowel devoicing on the surface, as seen in (16).[2] Vowels do not devoice with the same following surface segments in (17), however, since there is no underlying /h/ after these vowels. It may also be seen in other syllables of both words in (17) that not all voiceless consonants trigger devoicing on the vowel to their left. In particular, this process does not apply before voiceless stops.

(16) Comanche VD where coda [h] is deleted

a. [miʔ**ḁ**tsi] ‘having gone’ (from underlying /miʔ**a**htsi/)

b. [habik**ɯ̥**ni] ‘bedroom’ (from underlying /habik**a**hni/)

[2]As discussed in Chapter 1, the interaction between vowel devoicing and coda [h] deletion in Comanche is an example of a counter-bleeding relationship between VD and another phonological process. Such cases of opacity provide crucial evidence for phonological (rather than purely phonetic) vowel devoicing.

(17) No Comanche VD in similar surface environments to those in 16

a. [suʔ**a**tsitɯ] 'think about something, make a plan'

b. [pasap**u**ni] 'cross-eyed person'[3]

While interesting and relevant for the Comanche VD patterns, and evidence that this VD process does indeed take place within the phonology, language-specific details like the interaction with coda [h] deletion are the type of information that is not directly incorporated into the typological model of vowel devoicing developed in this dissertation, where the goal is to capture the cross-linguistic generalizations and patterns of VD. The interaction with coda [h] nevertheless provides an illustration of how language-specific details may be integrated in relation to the broader typological categories.

The examples of Comanche VD seen thus far also illustrate the prosodically non-restricted nature of this process. Whereas prosodically restricted processes occur in only one specific position within the relevant domain, Comanche's segmentally restricted devoicing is a domain span process, occurring in different positions throughout the word (i.e. different numbers of syllables from the right and left edges of the word). This is shown explicitly in (18). The two words have the same number of syllables, and in both examples, [ɯ̥] is devoiced before [s]. However, in (18a) which is repeated from (14a), the vowel in question is in the third syllable, whereas in (18b), it is in the second syllable.

(18) Comanche VD before /s/ in different positions of a word

a. [omom**ɯ̥**sɯ] 'on foot' (with intensifier)

[3]Stress was not marked in the original source for this example, but it is likely that the first syllable is stressed, explaining why the [a] in that position does not devoice before [s]. The role of stress is discussed next.

b. [sitɯ̥suʔa] ‘this one also’

Finally, before turning to the constraint-based analysis, it is interesting to note that Comanche also exhibits the more general cross-linguistic pattern mentioned in Chapter 3 pertaining to stressed syllables. That is, stressed syllables (the prosodic head of the word or foot) regularly block VD, even in the prosodically non-restricted category. Thus, as expected, the vowel in the first syllable does not devoice in (19) despite being followed by /s/, because it bears primary stress.[4]

(19) No Comanche VD in stressed syllables

['t**a**siˌʔa] ‘smallpox, freckles’

In sum, the key properties of Comanche vowel devoicing that must be addressed in the Optimality Theoretic analysis presented next are i) the segmental environments to which the process is restricted and ii) the fact that it can occur in different prosodic positions throughout the word but is blocked by stress. These components are precisely the ones needed to account for any (purely) segmentally restricted process.

[4]According to Robinson and Armagost (2012), Comanche has primary and secondary stress, which both block devoicing. Stress typically appears on alternating syllables but may be influenced to some extent by morphology. Robinson and Armagost also indicate that vowels cannot devoice in adjacent syllables. These details merit more targeted investigation, but I assume for the present purposes that the latter constraint on VD is a result of the alternating stress rather than an independent constraint against voiceless vowels in consecutive syllables. In any case, it seems clear that the interaction with stress requires an additional constraint on devoicing.

4.1.2 Comanche Segmentally Restricted VD in Optimality Theory

As discussed previously, there is a cross-linguistic absence of contrastive voiceless vowels. Their appearance in specific surface environments in some languages must therefore be driven by a markedness constraint requiring voiceless vowels in certain positions. Such a constraint must outrank a more general markedness constraint against voiceless vowels, such as *V[+spread glottis] or *V[-voice], that prevents them from occurring elsewhere.

In the case of (purely) Segmentally Restricted VD, as noted at the beginning of this section, the higher ranked constraint must be one that requires a voiceless or aspirated consonant to share a laryngeal feature with an adjacent vowel. In Comanche, /s/ and /h/ are the only consonants that trigger VD, so the laryngeal feature involved in the process must be specified for these two segments but not the other voiceless consonants in the language. I assume that this feature is [+spread glottis] (abbreviated [+SG]), following arguments in Vaux 1998 and Vaux & Miller 2011, among others, that voiceless fricatives, but not other voiceless (unaspirated) consonants, are specified for [+spread glottis] cross-linguistically.[5] In particular, I propose that VD is caused by a constraint *NonBranching[+SG], which requires [+spread glottis] features be associated with more than one segment.[6]

[5]Note that the evidence from Vaux 1998 and Vaux & Miller 2011 comes from phonological patterns across a variety of languages; however, there have also been phonetic arguments made for distinct laryngeal representations of voiceless stops and voiceless fricatives in several specific languages (e.g., Tsuchida 1997 on Japanese, and Tsuchida, Cohn, & Kumada 2000 on English).

[6]As noted in Chapter 3, laryngeal assimilation in Segmentally Restricted VD is always local (with one potential exception), spreading from a consonant only to one segment to its left or right. This is in contrast to feature harmony processes, which may span multiple segments. The *NonBranching constraint incorporates the local nature of VD, since it is fully satisfied once the feature is shared with only one additional segment, and thus distinguishes VD from other longer distance assimilation processes, which may be more insightfully accounted for with Align constraints.

This constraint can be understood as phonetically grounded in the tendency for glottal gestures to overlap (as noted in the phonetic perspectives on VD referenced in Chapters 1 and 2), which could lead to the gestures being more accurately produced and perceived if they span multiple segments and have more time for transitions. We must also ensure that [+spread glottis] only spreads to the left of the triggering consonant in Comanche. I account for the direction of spreading with a constraint *RightBranch. The four main constraints used in this analysis are defined in (20)-(23) below.

(20) *V[+SG] – vowels must not be associated with a [+spread glottis] feature.

(21) Ident[Lar] – segments in the output must be faithful to their corresponding segments in the input in their laryngeal feature specifications.

(22) *NonBranching[+SG] – [+spread glottis] features must be associated with more than one segment.

(23) *RightBranch - features must not spread rightward.

The interaction of these four constraints is illustrated in the tableau in (24) for the Comanche word [kupi̥simawa] 'croton weed' from example (14b), in which /s/ bears a [+spread glottis] feature in the input. In the output candidates, a voiceless diacritic (small circle) is used to indicate the [+spread glottis] property of vowels (e.g., i̥). Because I also include a candidate in which [+spread glottis] spreads beyond the devoiced vowel to the preceding consonant, I use an aspiration diacritic (superscript "h") to indicate the [+spread glottis] feature associated with a voiceless stop (e.g., p^h). Figure 4.1, below the tableau, shows the [+spread glottis] configurations I assume for each candidate in (24) more explicitly.

(24) Comanche /kupisimawa/ → [kupi̥simawa] ‘croton weed’

/kupisimawa/	*RightBranch	*NonBranching[+SG]	*V[+SG]	Id[Lar]
a. kupisimawa		∗!		
☞ b. kupi̥simawa			∗	∗
c. kupisi̥mawa	∗!		∗	∗
d. kup^{h}i̥simawa			∗	∗∗!

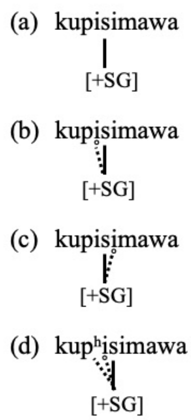

Figure 4.1: Output candidates of (24) showing their [+spread glottis] associations

As the tableau in (24) illustrates, vowel devoicing before voiceless fricatives in this analysis results from the ranking of *NonBranching[+SG] over both *V[+SG] and Ident[Lar] (abbreviated Id[Lar] in tableaux). This can be seen in a comparison between candidates (a) and (b). Candidate (a), the fully faithful candidate, avoids violations of both *V[+SG] and Ident[Lar] but violates the higher ranked *NonBranching[+SG], because the [+spread glottis] feature associated with [s] is not shared with any other segments. Thus, candidate (b) wins over candidate (a), because the former satisfies *NonBranching[+SG] by sharing the feature between [s] and the preceding vowel, despite its violation of the two lower ranked constraints. *RightBranch ensures that candidate (b) also wins over candidate (c), which satisfies *NonBranching[+SG] by devoicing the vowel to the right rather than the left of the [s], thereby accounting for the direction of feature spreading in Comanche VD. Finally, we see that the low ranked faithfulness constraint Ident[Lar] also ensures that feature spreading is limited to a single segment, because any additional spreading, as in candidate (d), incurs more violations of Ident[Lar] than the winner does without doing better than the winner on any higher ranked constraints. A candidate with more feature spreading than necessary to satisfy *NonBranching[+SG] is thus harmonically bounded by the winning candidate, in which [+spread glottis] has only spread to one adjacent segment.

Interestingly, if we consider a word that begins with a voiceless fricative, like [suʔatsitɯ] 'think about something, make a plan,' we can obtain further insight into the relationship between *RightBranch and *NonBranching[+SG]. In this context, leftward feature spreading from [s] to a preceding vowel in order to satisfy *NonBranching[+SG] is not possible. Instead, the options are either i) satisfy *NonBranching[+SG] by spreading the feature rightward instead, thus devoicing the following vowel and violating *RightBranch, or ii) leave a [+spread glottis] feature only associated with a single segment, satisfying *RightBranch but violating *NonBranching[+SG]. The fact that [suʔatsitɯ] surfaces as it does, without vowel devoicing, demonstrates that the latter option wins, and therefore that *RightBranch outranks *NonBranching[+SG]. This constraint ranking is illustrated in (25).

(25) Comanche /suʔatsitɯ/ → [suʔatsitɯ] 'think about something, make a plan'

/suʔatsitɯ/	*RightBranch	*NonBranching[+SG]	*V[+SG]	Id[Lar]
☞ a. suʔatsitɯ		*		
b. su̥ʔatsitɯ	*!		*	*

Thus, the basic pattern of vowel devoicing before voiceless fricatives in Comanche is accounted for with the following constraint ranking: *RightBranch >> *NonBranching[+SG] >> *V[+SG] >> Ident[Lar].

The Comanche case study also allows us to address the universal phenomenon in which stressed syllables resist VD. To account for this pattern, I propose a positional version of the general markedness constraint defined in (20), which prohibits voiceless vowels. The new constraint, *V[+SG]/ˈσ, is defined below in (26). This constraint follows the schema of positional markedness constraints formulated in J. Smith 2002 (introduced in Chapter 1 and discussed further in Chapter 5 of this dissertation) and can be understood conceptually along the same lines – as phonological augmentation, or enhanced perceptual salience, in prosodically strong syllables. That is, since voiceless vowels are much less acoustically salient than their voiced counterparts, as discussed in Chapter 2, a constraint against [+spread glottis] vowels in stressed syllables ensures a certain level of perceptual salience in that position.

(26) *V[+SG]/ˈσ– stressed vowels must not be associated with a [+spread glottis] feature.

Whereas *NonBranching[+SG] outranks the general markedness constraint against voiceless vowels, the positional constraint must outrank *NonBranching[+SG]. This is illustrated in the tableau in (27), which shows stress blocking vowel devoicing in the first syllable of the word [ˈt**a**siˌʔa] ‘smallpox, freckles' from example (19). (Note that because a complete analysis of the Comanche stress system is outside the scope of this case study, all output candidates have the same stress placement.)

(27) Comanche /tasiʔa/ → [ˈtasiˌʔa] 'smallpox, freckles'

/tasiʔa/	*V[+SG]ˈσ	*RightBranch	*NonBranching[+SG]	*V[+SG]
☞ a. ˈtasiˌʔa			*	
b. ˈtḁsiˌʔa	*!			
c. ˈtasi̥ˌʔa		*!		

Finally, it should be noted that another possible way to satisfy *NonBranching[+SG] when leftward spreading of the feature is not viable might be to delete the [+spread glottis] feature from the voiceless fricative all together, which would presumably result in a voiced fricative (e.g., [ˈtaziˌʔa]). There are no voiced fricatives at all in Comanche, so we may assume that this alternative strategy for satisfying *NonBranching[+SG] is prohibited by an inviolable markedness constraint against such segments (which would also serve to constrain the consonant inventory to only the segments attested in the language more broadly). Another option might be to include a highly ranked faithfulness constraint for consonants that prevents changes in their laryngeal features. Either way, the only strategy for satisfying *NonBranching[+SG] that we observe is vowel devoicing to the left of the voiceless fricative. More generally, any alternative strategies of satisfying *NonBranching[+SG] must be ruled out by higher ranked constraints.

4.1.3 Extension to other processes of (purely) Segmentally Restricted Vowel Devoicing

This section has developed an Optimality Theoretic analysis of Segmentally Restricted VD before voiceless fricatives in Comanche, using a phonetically grounded markedness constraint against non-branching [+spread glottis] features: *NonBranching[+SG]. This constraint must outrank a general markedness constraint against voiceless vowels as well as a faithfulness constraint Ident[Lar], which prohibits changing laryngeal specifications from input to output. The direction of feature spreading is determined by a higher ranked constraint that prohibits feature spreading in the other direction.

A similar analysis may be applied to other processes of Segmentally Restricted VD triggered by a voiceless or aspirated consonant to the right of the vowel. This includes Cheyenne VD before voiceless fricatives, as described in Section 3.2.1, as well as others in the VD Database included in the appendices to this dissertation. To account for Segmentally Restricted VD triggered by a consonant to the left of the vowel instead, such as the process after voiceless fricatives in Niaufo'ou, also described in Section 3.2.1, we need only to change the constraint on the direction of feature spreading to *LeftBranch. The *NonBranching constraint may also be better formulated with reference to a different laryngeal feature in some cases, depending on the specific voiceless or aspirated consonants that trigger a particular segmentally restricted process. Chapter 5 will discuss the relationship between the consonants involved in a segmentally restricted process and the larnygeal feature used to account for it in greater depth.

Different types of markedness constraints may also be better suited for some segmentally restricted processes. For example, processes that specifically target vowels between two voiceless consonants may be accounted for with constraints against "voicing contours," as proposed by Tsuchida (1997, 2001) for Japanese. Crucially, however, this type of constraint is phonetically grounded in the same principle as *NonBranching[+SG], and must interact in a similar way with the other constraints introduced for the Comanche case study. That is, a constraint against "voicing contours" can also be motivated by the idea that longer laryngeal feature spans provide more time to transition between glottal states, allowing for more accurate production and perception, and it must also outrank the general markedness constraint against voiceless vowels and the faithfulness constraint Ident[Lar].

Another important generalization to be made from this analysis has to do with the specific way in which segmentally restricted VD processes are blocked by a particular strong position but otherwise apply freely across an entire prosodic domain. I have accounted for blocking of VD with a positional markedness constraint against [spread glottis] vowels in stressed syllables. Because VD rarely or never occurs in stressed syllables (or positions associated with abstract prosodic heads) cross-linguistically, this constraint must always be relatively highly ranked, crucially, outranking the markedness constraint responsible for VD elsewhere. The fact that the markedness constraints responsible for purely segmentally restricted VD refer only to the segmental environment (not a specific prosodic position) guarantee that unless devoicing is blocked by another constraint, it will occur anywhere in the relevant prosodic domain that the segmental conditions are met. Interestingly, in Niuafo'ou, both stressed syllables and word-initial syllables block vowel devoicing (Tsukamoto 1988). This suggests that a similar positional markedness constraint referring to word-initial syllables (another strong position) may also be necessary in some cases.

Thus, while details of the markedness constraint triggering Segmentally Restricted VD may vary from process to process is specific, limited ways, the same types of constraint interactions should hold for all processes in this category of VD.

4.2 Formal analysis of (purely) Prosodically Restricted Vowel Devoicing

As noted at the beginning of this chapter, all vowel devoicing phenomena must involve some interaction between a constraint that prohibits voiceless vowels in general, and another one that requires voiceless vowels in specific environments. While (purely) Segmentally Restricted VD can be attributed to a markedness constraint that targets a laryngeal feature associated with a consonant (i.e. the segmental environment) and causes the feature to spread to an adjacent vowel, (purely) Prosodically Restricted VD, by definition, ignores the segmental environment. Prosodically Restricted VD must therefore be accounted for by a fundamentally different type of constraint. In particular, I propose that the crucial type of constraint in this case is a positional markedness constraint that requires voiceless vowels in prosodically weak positions. As I will demonstrate, these constraints also differ in a fundamental way from the more established positional markedness constraints relativized to strong positions. That is, while positional markedness in strong positions serves to enhance or maintain perceptual salience, positional markedness in weak positions has the opposite effect: the reduction of perceptual salience.

In this section, I return to the case of word-final VD in the Wallaga variety of Oromo (Cushitic) introduced in Chapter 3. As was done for the case study of Comanche, I first review the basic pattern of Wallaga Oromo VD, and then present a constraint-based analysis of the phenomenon. Finally, as with the segmentally restricted case study, I address ways in which this analysis can be extended to other instances of (purely) Prosodically Restricted VD.

4.2.1 Basics of Wallaga Oromo vowel devoicing

The present analysis of Wallaga Oromo VD is based on the data and description in Dissassa (1980)'s Master's Thesis on the language's phonology. Wallaga Oromo has a relatively large phoneme inventory, as seen in Table 4.3 for the consonants, and Table 4.4 for the vowels.

	Bilab	**Lab-dent**	**Dent**	**Alv**	**Alv-pal**	**Retr**	**Pal**	**Vel**	**Glot**
Stop	b		t d			ʈ		k g	ʔ
Affricate					ʧ ʤ				
Ejective	p'		t'	s'	ʧ'			k'	
Fricative		f		s	ʃ				h
Nasal	m		n				ɲ		
Glide							j	w	
Liquid				l r					

Table 4.3: Wallaga Oromo consonant inventory (based on Dissassa 1980)

	Front	**Central**	**Back**
High	i ɪ		u ʊ
Mid	e ɛ	ə	o ɔ
Low			a

Table 4.4: Wallaga Oromo vowel inventory (based on Dissassa 1980)

The inventory in Table 4.3 shows that obstruents may be either voiceless or voiced, with voicing contrasts in at least some manners and places of articulation, whereas sonorants are all voiced. The segmental context is not relevant for the phenomenon of word-final VD in Wallaga Oromo, however, since, as a purely prosodically restricted process, it may apply in any segmental environment, irrespective of the laryngeal properties of adjacent segments. VD can also affect all vowel qualities. Examples (28a) and (28b) show word-final devoicing after both voiced and voiceless obstruents, respectively, and (28c) shows devoicing after a sonorant. All examples in this section come from Dissassa 1980.

(28) Wallaga Oromo word-final VD after any type of consonant

a. [ˈɪʤ**ḁ**] ‘eye’

b. [fiˈgiʧ**ḁ**] ‘run’

c. [ˈk’om**o̥**] ‘race’

These examples also illustrate the prosodically restricted nature of Wallaga Oromo VD. While all vowels devoice at the right edge of the word, no vowels devoice word-initially or medially in any segmental environment. A more explicit comparison between word-final and non-final environments is provided in (29a) and (29b), which are repeated from Section 3.2.2. Both examples contain an unstressed /a/ in the same segmental environments (i.e. following /r/), but in the first example, this vowel is in word-final position and thus devoices, whereas in the second example, it is word-medial and thus does not devoice.

(29) Wallaga Oromo VD after [r] in word-final but not medial environments

a. [ˈnar**ḁ**] ‘brow’

b. [wər**a**ˈbesḁ] ‘hyena’

Finally, it is important to note that vowels do not devoice in the final syllable if that syllable has a coda, as illustrated in (30). This further confirms the restriction of Wallaga Oromo VD to the final segment of a word, rather than to the final syllable.

(30) No Wallaga Oromo VD before a final coda:
[ɪˈmɪm**a**n] 'tear'

4.2.2 Wallaga Oromo Prosodically Restricted VD in Optimality Theory

As discussed in Chapter 1, interactions between prosodic structure and segmental phonology, in which specific prosodic positions license, trigger, or block certain segments or segmental processes, are insightfully accounted for with positional constraints in Optimality Theory. The Wallaga Oromo VD pattern, where all word-final vowels are voiceless and all other vowels are voiced, reflects surface preferences for different segmental material in different prosodic positions, evidence of a positional markedness effect. This is in contrast to positional faithfulness effects, which result in the maintenance of a contrast in one position and neutralization of that contrast elsewhere. Of course, since voiceless vowels are not contrastive, the appearance of voiceless vowels on the surface can never be accounted for with faithfulness more broadly, as also noted in Chapter 1.

The Wallaga Oromo VD phenomenon is particularly interesting in exploiting a positional markedness constraint in a prosodically weak position, specifically, the end of the word. As such, it differs from the more typical positional effects attributed to positional markedness constraints associated with strong positions (e.g., word-initial or stressed syllables). While positional markedness constraints in strong positions serve to ensure or enhance perceptual salience of segments (J. Smith 2002), I propose that positional markedness constraints in weak positions have the opposite effect, reducing perceptual salience. As will be discussed further in the next chapter, both positional effects are observed in the vowel devoicing typology. In fact, it has already been seen in this dissertation that strong positions tend to block VD processes that apply elsewhere in the word. Since voiceless vowels are realized with lower intensity and less salient place and pitch information than voiced vowels, blocking of VD in strong positions ensures the salience of vowels in those environments. What we now see in Wallaga Oromo (and other prosodically restricted processes) is the opposite effect, where word-final positions trigger VD, reducing the perceptual salience of vowels in a specific prosodically weak position.

In order to account for Wallaga Oromo VD, what is needed specifically is a positional markedness constraint that requires word-final vowels to be associated with a [+spread glottis] feature: V[+SG]/$]_\omega$, where $]_\omega$ indicates the right edge of a word. In addition, two general constraints are required. One is the basic markedness constraint against voiceless vowels seen previously in the case study of Comanche, and indeed assumed cross-linguistically, given the marked status of voiceless vowels: *V[+SG]. The other is a faithfulness constraint, Dep[Lar], that prohibits the insertion of laryngeal features from an input to an output. These constraints and their definitions are provided in (31) – (33).

(31) V[+SG]/$]_\omega$ - word-final vowels must be associated with a [+spread glottis] feature.

(32) *V[+SG] - vowels must not be associated with [+spread glottis] features.

(33) Dep[Lar] - laryngeal features must not be inserted.

$V[+SG]/]_\omega$ must outrank the other two constraints, as shown in (34) for the word [ˈnarḁ] 'brow,' from example (29a).

(34) Wallaga Oromo /nara/ → [ˈnarḁ] 'brow'

/nara/	$V[+SG]/]_\omega$	DEP[LAR]	*V[+SG]
a. nara	*!		
☞ b. narḁ		*	*

In this tableau, the word-final /a/ devoices after a sonorant, /r/, which does not bear its own [+spread glottis] feature, so the [+spread glottis] feature on the final [ḁ] in the output can only arise via feature insertion. Thus, the ranking of $V[+SG]/]_\omega$ >> DEP[Lar] ensures that word-final vowels are voiceless even when [+spread glottis] cannot spread from an adjacent voiceless or aspirated segment and must instead be inserted, violating the faithfulness constraint. Of course, the ranking of $V[+SG]/]_\omega$ >> *V[+SG] also ensures that voiceless vowels are permitted in word-final positions despite being prohibited more generally. Note that the positional markedness constraint must also outrank IDENT[Lar], just as the constraint responsible for (purely) Segmentally Restricted VD does.

4.2.3 Extension to other processes of (purely) Prosodically Restricted Vowel Devoicing

As the analysis of vowel devoicing in Wallaga Oromo illustrates, (purely) Prosodically Restricted VD may be accounted for quite simply with a positional markedness constraint (here, $V[+spread\ glottis]/]_\omega$), which requires a voiceless vowel in a single (weak) prosodic position. It was demonstrated above that this positional markedness constraint must outrank a general markedness constraint against voiceless vowels, which are cross-linguistically dispreferred (*V[+SG]). The positional markedness constraint must also outrank a basic faithfulness constraint against laryngeal feature insertion, Dep[Lar], to ensure that voiceless vowels appear even without adjacent voiceless or aspirated consonants.

The approach developed for Wallaga Oromo can be applied straightforwardly to the other (purely) prosodically restricted VD phenomena in the VD Database. For other word-final processes, the same positional markedness constraint can be used. For processes that are restricted to other prosodic positions, only minimally different formulations of the constraint are needed. For instance, vowel devoicing restricted to the right edge of a phonological phrase would require a positional markedness constraint making reference to phrase-final rather than word-final vowels (e.g., $V[+SG]/]_{\phi}$, where ϕ = phonological phrase). The constraint may also be modified to target any vowel in a domain-final syllable instead of the domain-final segment (e.g., $V[+SG]/\sigma_{\text{final}}$). This would result in vowel devoicing in domain-final syllables whether they are open or closed.

Finally, not only are the positional markedness constraints responsible for (purely) Prosodically Restricted VD across languages essentially the same (with the minimal variations just noted), but the same types of constraint interactions observed in Wallaga Oromo are also relevant for other languages. That is, the positional markedness constraint must always require voiceless vowels in some prosodically weak environment, and this constraint must outrank both a more general markedness constraint against voiceless vowels as well as a faithfulness constraint against feature insertion.

4.3 Formal analysis of Prosodically and Segmentally Restricted Vowel Devoicing

The third, and final, category of vowel devoicing is restricted with respect to both the prosodic and segmental parameters, thus sharing certain properties with each of the other two types of VD. In this section, the case study of Cheyenne word-final VD before voiceless obstruents allows us to see how the prosodic and segmental parameters can interact. In the phonological analysis of this process, I demonstrate that the prosodically and segmentally restricted category may in fact be unified with the other prosodically restricted processes addressed in Section 4.2, such that the two prosodically restricted categories crucially differing only in the relative ranking of two constraints. While the third category of VD does share certain descriptive properties with the purely segmentally restricted category, the nature and sources of the segmental restrictions arise from different aspects of the formal analysis.

Cheyenne word-final VD interacts in important ways with the rest of the language's phonology, so I first present a basic introduction to Cheyenne phonology before describing the VD process itself. I then demonstrate how Cheyenne word-final VD can be accounted in a straightforward way using the same types of constraints introduced for (purely) Prosodically Restricted VD in Section 4.2. Finally, as with the analyses of the other two types of VD, I discuss how the analysis of Cheyenne word-final VD may be extended to the category of Prosodically and Segmentally Restricted VD more generally.

4.3.1 Basics of Cheyenne phonology and word-final vowel devoicing

The analysis of Cheyenne word-final vowel devoicing presented here is based on descriptions and data in Leman & Rhodes 1978, Leman 1980, 2011, and Fisher et al. 2017, and follows the analysis developed in R. Vogel 2020, 2021. To put the present analysis in context, it is important to also consider certain other aspects of Cheyenne phonology, including its phoneme and tone inventory as well as some relevant phonotactic constraints. The consonant and vowel inventories are provided in Tables 4.5 and 4.6 below.

	Bilabial	**Dental**	**Post-Alveolar**	**Velar**	**Glottal**
Stops	p	t		k	ʔ
Affricates		(ts)			
Fricatives		s	ʃ	(x)	h
Nasals	m	n			
Glides	v				

Table 4.5: Cheyenne consonant inventory (based on Leman 1980, 2011)

	Front	**Central**	**Back**
Mid	e		o
Low		a	

Table 4.6: Cheyenne vowel inventory (based on Leman 1980, 2011)

As can be seen in Table 4.5, all obstruents are voiceless. Note that in Leman 1980, 2011, /v/ is included as a voiced fricative, but it is shown as a glide here. The present interpretation is based on several considerations. First, it can be observed that there are no other voiced obstruents, and it would be unusual to have this relatively marked segment as the only such obstruent in the language. Moreover, there is no corresponding voiceless fricative in the same place of articulation, which would be expected on the basis of typical implicational relations between voiced and voiceless obstruents. Instead, it seems more insightful to consider /v/ a sonorant (i.e. glide), and in fact, Leman has described this segment as having variable realizations including typical glide-like [w] or [ʋ]. The two consonants in parentheses are allophones of other phonemes. Specifically, [x] is an allophone of /ʃ/ and /h/ said to surface from the former when followed by [a] or [o], and from the latter when followed by another [h] (Leman 2011); [ts] is an allophone of /t/ that surfaces before [e]. Cheyenne also has a contrast between high and low tone. As in Chapter 3, high tone is marked with an acute accent here, and low tone is not marked, following Cheyenne orthography.

In terms of phonotactics, in word-internal positions, Cheyenne allows certain sequences of two consonants, where the first may be assumed to be a coda, as illustrated in (35). The clusters are shown in bold.

(35) Word-internal consonant clusters in Cheyenne (Fisher et al. 2017)

a. [mḁ**ht**ao**ʔk**eme] ‘coffee bean’

b. [heʔékaʔe̥**ʃk**óne] ‘girl’

Word-finally, however, codas are not permitted. Underlying word-final sonorants delete, and underlying word-final obstruents are followed on the surface by an epenthetic [e], represented as <e> in the rest of this section, as well as in the next chapter. The latter results in the underlying word-final syllable appearing in the penultimate position on the surface. These word-final processes are shown in (36) - (38), where the (a) forms are plural nouns consisting of a root followed by one of several plural suffixes. The (b) forms are the corresponding singular forms, where the root is not followed by a suffix, allowing us to compare root-final segments in word-medial and word-final environments. Morpheme breaks between the roots and suffixes are shown with dashes.

(36) Deletion of word-final nasals in Cheyenne (Leman 1980, 2011)

a. [póéso**n**-o] ‘cats’

b. [póéso] ‘cat’

(37) <e> epenthesis after word-final fricative in Cheyenne (Fisher et al. 2017)

a. [hóhkó**x**-e̥stse] ‘axes’[7]

b. [hóhko̥**x**<e>] ‘axe’

(38) <e> epenthesis after word-final stop in Cheyenne (Leman 1980, 2011)

a. [ʃéʃenovo**t**-o] ‘snakes’

b. [ʃéʃenovo̥**ts**<e>] ‘snake’

The plural forms provide evidence that all three noun roots end in a consonant. In ‘cats’ in (36a), the plural suffix /-o/ follows an [n], indicating that the root ends in an underlying nasal. This /n/ is deleted in the singular form ‘cat,’ however, since it is not permitted in word-final position. Similarly, the plural suffixes in (37a) and (38a) allow us to see that the roots of ‘axe’ and ‘snake’ end in an underlying fricative and stop respectively. In the singular forms of these nouns, which lack a suffix, the root-final consonants again do not appear in word-final position. Unlike the root-final nasal which is deleted, however, the fricative and stop are followed by epenthetic <e> in (37b) and (38b). In the latter, the /t/ is then produced as the [ts] allophone.

[7] The final [e] of the suffix in ‘axes’ is also epenthetic, but it is not marked with angled brackets, since it is not relevant for the noun root alternations under discussion.

The Cheyenne process of prosodically and segmentally restricted VD targets vowels specifically before voiceless consonants in the underlying word-final syllable. Crucially, this occurs in precisely the same words that undergo <e> epenthesis after word-final obstruents, so the word-final environment of this VD process is systematically obscured on the surface. We therefore see VD in surface penultimate syllables before voiceless consonants in some words, like ‘axe’ and ‘snake,’ as well as in the plural suffix of ‘axes’ repeated in (39), but not in the same surface environments in other words, such as ‘alien’ in (40a), where <e> epenthesis has not taken place and the surface penultimate syllable is thus also the underlying penult. (In (40b), we see that the plural suffix in ‘aliens’ comes after a root ending in [e] rather than a consonant, indicating that the [e] seen at the end of the singular is underlying rather than epenthetic.) In fact, all surface penultimate syllables that exhibit VD are underlying word-final syllables.[8]

(39) Cheyenne VD before voiceless consonants in the underlying word-final syllable

a. [hóhk**o̥**x<e>] ‘axe’

b. [ʃéʃenov**o̥**ts<e>] ‘snake’

c. [hóhkóx**e̥**sts<e>] ‘axes’

(40) No Cheyenne VD before voiceless consonants in the underlying penultimate syllable (Fisher et al. 2017)

a. [n**o**tse] ‘alien’

b. [nótse-oʔo] ‘aliens’

[8]It may be recalled from Chapter 3 that the prosodically non-restricted process of VD in Cheyenne is blocked by prosodic prominence in the penultimate syllable. Interestingly, in words that have undergone word-final <e> epenthesis, the surface antepenultimate syllable, which corresponds to the underlying penult resists VD, as in [táhoxeʔe̥stón**e**so̥ts<e>] ‘desk’ (Leman & Rhodes 1978).

Because this process is both prosodically and segmentally restricted, we do not see VD when the conditioning requirements are met for only one of the two parameters. That is, we do not get devoicing in the word-final syllable when the vowel is followed by a voiced consonant in the underyling form, as in 'cat' in (36b) earlier in this section, or when the final syllable is open in the underlying form, as in 'alien' in (40a) above. Additionally, while vowels do devoice before voiceless fricatives elsewhere in the word as a result of the prosodically non-restricted process described in Chapter 3, they do not devoice before other voiceless consonants outside of the underlying word-final syllable, as shown in the second syllable of (41).

(41) No Cheyenne VD before a voiceless affricate outside the penultimate syllable: [véhp**o**tséhohpe] 'tea' (Fisher et al. 2017)

Thus, in order to correctly account for the application of Cheyenne prosodically and segmentally restricted VD, we must make reference both to the segmental environment to the right of the vowel and to the underlying (rather than surface) prosodic position.

4.3.2 Cheyenne Prosodically and Segmentally Restricted VD in Optimality Theory

The analysis presented here is part of a larger analysis involving a number of phonological processes in Cheyenne within the framework of Stratal Optimality Theory (Bermúdez-Otero 2018; Kiparsky 2000). In that analysis (see R. Vogel 2020, 2021), I examine the opaque relationship between <e> epenthesis and several other processes, including word-final VD, and argue that word-final VD must apply at the word stratum, whereas word-final <e> epenthesis occurs at the phrase stratum. For the present purposes, however, I focus on the constraint rankings necessary to produce word-final VD at the word stratum, since this is the component of the analysis that pertains to the typological goals of this dissertation; the other language-specific details are orthogonal to the broader issues under consideration here.[9]

As a prosodically and segmentally restricted vowel devoicing process, Cheyenne word-final VD is prosodically limited to a specific weak position, like Wallaga Oromo, and segmentally limited to contexts where it is adjacent to a voiceless consonant, like Comanche. These properties make Cheyenne word-final VD best understood as a process of laryngeal assimilation in one specific prosodic position. As demonstrated for Wallaga Oromo, prosodically restricted VD is most effectively accounted for with a positional markedness constraint that makes direct reference to the specific (weak) position in which the voiceless vowels occur. Thus, like for Wallaga Oromo, the analysis of the Cheyenne process includes a markedness constraint requiring word-final vowels to be voiceless. However, unlike the Wallaga Oromo constraint, the Cheyenne constraint must target the word-final syllable rather than the final segment, since it applies in syllables with voiceless codas. (Recall this analysis focuses on the word stratum, before <e> epenthesis has occurred, so the voiceless consonants are indeed codas.) The positional markedness constraint

[9] To briefly describe the approach taken in R. Vogel 2020, 2021 that ensures that <e> epenthesis is delayed until the phrase stratum, I assume that at the word stratum, faithfulness constraints against epenthesis and deletion of segments outrank a constraint against word-final codas, *Coda/]$_\omega$. This keeps word-final consonants in their underlying position. Then, at the phrase stratum, *Coda/]$_\omega$ gets promoted to an undominated status, allowing deletion and epenthesis in order to avoid word-final codas. The specific faithfulness constraints I use are regular Dep and Max, as well as Max-Obstruent. At the phrase stratum, the ranking of *Coda/]$_\omega$ Max-Obstruent >> Dep >> Max, causes sonorants to be deleted, but epenthesis to occur after obstruents to avoid their deletion.

I use is provided, with its definition, in (42). Note that the Cheyenne constraint refers to [-voice] rather than [+spread glottis] for language-specific reasons to be discussed in greater detail in Chapter 5.

(42) V[-voice]/$\sigma]_\omega$ - vowels in word-final syllables must be associated with a [-voice] feature.

Recall that for Wallaga Oromo, in order for VD to occur in any segmental environment, the positional markedness constraint must outrank the faithfulness constraint against insertion of laryngeal features, DEP[Lar]. This allows vowels in the proper prosodic position to devoice even when there is no adjacent voiceless or aspirated consonant with which it can share a laryngeal feature. In order to account for the additional segmental restriction in Cheyenne, all that is needed is to reverse the ranking: DEP[Lar] >> V[-voice]/$\sigma]_\omega$. This permits vowels to devoice in the proper prosodic position only when they can assimilate in [-voice] to an adjacent voiceless consonant, as shown in the tableau in (43). In other segmental environments, devoicing does not occur, because it would require insertion of [-voice], violating the higher ranked DEP[Lar], as shown in the tableau in (44). Note that the analysis of Cheyenne also includes the general markedness constraint against voiceless vowels (*V[-voice]). As in any language with voiceless vowels, however, this constraint must be outranked by the constraint requiring voiceless vowels to appear in the necessary position, while preventing them from appearing elsewhere. As in the analyses of the other two types of VD, I assume that the constraint responsible for VD (in this case V[-voice]/$\sigma]_\omega$) must also outrank IDENT[Lar]. Recall that the relevant level of consideration in both (43) and (44) is the word stratum, so the winning candidates are the inputs to the phrase stratum rather than the surface forms.

(43) Cheyenne /ʃéʃenovot/ → ʃéʃenovo̥t ‘snake’

/ʃéʃenovot/	Dep[Lar]	V[-voice]/$\sigma]_\omega$	*V[-voice]
a. ʃéʃenovot		*!	
☞ b. ʃéʃenovo̥t			*

(44) Cheyenne /póésono/ → póésono ‘cat’

/póésono/	Dep[Lar]	V[-voice]/$\sigma]_\omega$	*V[-voice]
☞ a. póésono		*	
b. póésono̥	*!		*

In (43), the final vowel of /ʃéʃenovot/ ‘snake’ (which ultimately will surface as [ʃéʃenov**o̥**ts<e>]) is in a position where it can share the [-voice] feature associated with the voiceless stop to its right. As such, we observe VD, without a violation of Dep[Lar]. In (44), in contrast, the final vowel of /póésono/ ‘cats’ can only devoice if [-voice] is inserted. The candidate in (b), which has undergone vowel devoicing, is therefore eliminated by Dep[Lar].

Finally, it should be noted that word-final VD also does not occur in syllables with voiceless onsets if they do not also have a voiceless coda. For example, there is no word-final devoicing in [maʔaet**a**] ‘iron, metal’ (Fisher et al. 2017). This suggests that [-voice] can only spread leftward, not rightward. I propose that the constraint *RightBranch introduced for Comanche also outranks V[-voice]/$\sigma]_\omega$ in Cheyenne, preventing rightward spreading from the onset to the nucleus. Thus, in words such as [maʔaeta], there is no way for the word-final vowel to devoice without violation of some high ranked constraint.

4.3.3 Extension to other processes of Prosodically and Segmentally Restricted Vowel Devoicing

Section 4.3 has thus far demonstrated how the Optimality Theoretic analysis of (purely) Prosodically Restricted VD from Section 4.2 can be modified to account for the Cheyenne process of Prosodically and Segmentally Restricted VD. While (purely) Prosodically Restricted VD was attributed to a positional markedness constraint that outranks a faithfulness constraint against feature insertion, Cheyenne word-final VD before voiceless consonants is accounted for with the same types of constraints in the reverse ranking: faithfulness over positional markedness (Dep[Lar] >> V[-voice]/$\sigma]_\omega$).

The same basic approach can be extended to other prosodically and segmentally restricted VD processes, with minor variation in the formulation of the positional markedness constraint responsible for devoicing depending on language-specific details. For example, as discussed in the context of (purely) Prosodically Restricted VD, the positional markedness constraint may refer to slightly different prosodic positions (e.g., final segment vs. final syllable, or phrase-final vs. word-final).

Additionally, depending on the segmental environments to which VD is restricted, the constraint may refer to different laryngeal features. For instance, in Cheyenne, word-final VD occurs adjacent all voiceless consonants, which along with some other phonological facts in the language, supports an analysis using [-voice] rather than [+spread glottis] (see further discussion in Chapter 5). In Ecuadorian Spanish, on the other hand, word-final VD occurs adjacent to voiceless fricatives but not other voiceless consonants (Lipski 1990), supporting the use of [+spread glottis] instead. This also highlights an interesting distinction between the prosodically and segmentally restricted category of VD and the purely prosodically restricted category. In the former, because vowels devoice by assimilating to adjacent consonants, the laryngeal representation of those consonants determines the laryngeal representation of the devoiced vowels. In the latter, because vowels can devoice without assimilating to adjacent consonants, there is not always conclusive phonological evidence for one particular laryngeal feature over another.

While the prosodic positions and laryngeal features targeted by the positional markedness constraint may vary in specific ways, the basic approach developed for Cheyenne applies to all processes in the prosodically and segmentally restricted category. First, these processes are always be triggered by a positional markedness constraint that requires vowels in a prosodically weak position to be voiceless. As discussed for (purely) Prosodically Restricted VD, these constraints serve to reduce perceptual salience in weak positions. Second, a higher ranked faithfulness constraint, Dep[Lar], prevents feature insertion to satisfy the positional markedness constraint, allowing VD to occur in the targeted prosodic position only if there is an adjacent voiceless or aspirated consonant with the relevant laryngeal feature.

4.4 Discussion

This chapter has presented an Optimality Theoretic account of the three main categories of vowel devoicing identified in the typological model from Chapter 3. This approach makes a clear commitment to both the types of constraints and the constraint interactions necessary for each category of VD; however, it crucially leaves room for some specific forms of variation in the constraints involved from language to language. In this way, the model not only captures cross-linguistic generalizations, it is also able to account for the finer-grained language-specific details within each category of vowel devoicing as observed in the VD Database.

In particular, I demonstrated that the purely segmentally restricted processes are triggered by a markedness constraint that targets a specific laryngeal feature. This feature may differ depending on the particular set of segmental environments in which a VD process can occur, as well as other aspects of a language's phonology, but it must be one associated with a relatively open glottis and must be able to identify the appropriate set of voiceless or aspirated consonants to trigger VD. (The laryngeal representations of vowel devoicing will be discussed further in Chapter 5.) Crucially, the constraints responsible for (purely) Segmentally Restricted VD do not target the vowels themselves, but effectively cause a laryngeal feature typically associated with consonants in the input to be spread to adjacent vowel segments in the output. Because this constraint also does not refer to a particular prosodic position, it can affect the laryngeal feature in question anywhere it appears within the relevant prosodic domain, accounting for the domain span nature of (purely) Segmentally Restricted VD. I proposed that this type of constraint may be understood as phonetically grounded in the tendency for glottal gestures to overlap.

The fact that stressed syllables consistently block Segmentally Restricted VD cross-linguistically was accounted for in this approach simply with a highly ranked positional markedness constraint against voiceless vowels in stressed syllables. Since voiceless vowels are less acoustically salient than voiced vowels, this constraint can be understood as a means of ensuring perceptual salience in strong positions, in line with the conception of positional markedness advanced in the prior literature (e.g., J. Smith 2002).

As far as the prosodically restricted processes are concerned, I have proposed that the simplest and most insightful account is achieved with positional markedness constraints that require vowels to be voiceless in weak prosodic positions. These constraints have the opposite effect of positional markedness in strong positions – that is, reduced perceptual salience rather than enhanced perceptual salience. (The status of positional markedness in weak positions will also be discussed further in Chapter 5.)

Moreover, it was seen that different interactions between these positional markedness constraints and a faithfulness constraint prohibiting (laryngeal) feature insertion yield the two different types of prosodically restricted patterns in the typology. When positional markedness outranks faithfulness, we get (purely) Prosodically Restricted VD; however, when faithfulness outranks positional markedness, we get restrictions from both prosodic and segmental parameters, resulting in the prosodically and segmentally restricted category. In this way, (purely) Prosodically Restricted VD and Prosodically and Segmentally Restricted VD can be unified as two variants of the same type of vowel devoicing phenomenon, attributed to a preference for less perceptually salient vowels in a specific prosodic position. In contrast, (purely) Segmentally Restricted VD, requires a fundamentally distinct approach, relying on the featural properties of individual segments.

CHAPTER 5

THEORETICAL IMPLICATIONS OF THE PHONOLOGICAL APPROACH TO VOWEL DEVOICING

Chapters 3 and 4 have identified three major categories of vowel devoicing based on the roles of segmental and prosodic structure in conditioning their application and provided a phonological analysis in Optimality Theory of each of the categories. Chapter 3 also introduced three finer-grained patterns concerning the types of segmental and prosodic factors involved in each of the three categories that emerged from the Vowel Devoicing Database, and Chapter 4 suggested ways in which these patterns of variation within each category can be captured within the formal analysis. The present chapter discusses three specific findings and insights from these chapters in greater detail. As will be seen, each issue bears on more general theoretical issues in phonology, and allows us to consider the broader implications of the vowel devoicing phenomena in question.

First, in Section 5.1, I discuss the laryngeal representations of devoiced vowels, drawing on evidence from the different sets of triggering consonants seen across the segmentally restricted processes in the VD Database. I argue that in order to account for the full range of segmental restrictions that we find cross-linguistically, as well as in individual languages that exhibit multiple segmentally restricted processes, we must make use of both [+spread glottis] and [-voice] features, which in turn has implications for the debates regarding the nature of laryngeal features in Feature Theory.

Second, in Section 5.2, I return to the issue of positional markedness constraints in prosodically weak positions introduced in the Optimality Theoretic analysis in Chapter 4. In this section, I present a more explicit argument for why positional markedness constraints in both strong and weak positions are necessary to account for the full range of vowel devoicing phenomena observed cross-linguistically. I then discuss the implications of their inclusion in phonological theory for our understanding of the relationship between prosodic structure and segmental phonology more broadly.

Finally, in Section 5.3, I present a more detailed examination of domain-final VD, focusing on the relationships between prosodic and segmental conditioning factors, and between processes occurring at the ends of different sized domains. I propose that the diachronic concept of domain generalization provides critical insight into both of these issues, and it also sheds light on more detailed distributional patterns found within the VD Database.

5.1 Laryngeal representations

As discussed in Chapter 1 of this dissertation, previous phonological analyses of vowel devoicing have made use of different laryngeal representations. Earlier featural accounts of Japanese VD (e.g., McCawley 1968) assumed voiceless vowels were specified for [-voice], whereas more recent works on Japanese and some other languages have either assumed, or explicitly argued, that voicelessness in vowels was associated with a [spread glottis] feature instead (e.g., Cho 1993 on Comanche and Acoma; Tsuchida 1997, 2001 on Japanese; Louie 2010 on Northern Paiute). Regardless of the feature selected, this prior work typically shares the view that only one laryngeal feature is necessary to account for vowel devoicing, the choice depending on which feature was supported by stronger evidence. Independently of the issues relating to vowel devoicing, there have also been compelling arguments provided in favor of treating [voice] as a privative rather than a binary feature in

Feature Theory (e.g., Brown 2016; Cho 1990; Lombardi 1991, 1995; Mester & Itô 1989, but see work such as W. G. Bennett & Rose 2017 for another perspective). Since these arguments have been primarily based on phonological evidence from processes involving consonants, however, it is not obvious that they can simply be extended to the laryngeal representation of vowels. Thus, closer examination of features involved in the analysis of voiceless vowels allows us to investigate the nature of laryngeal features from a broader phonological perspective. Specifically, if [-voice] is needed to characterize voiceless vowels, [voice] must be a binary feature, for with both "+" and "-" values are available. If, however, the [spread glottis] feature is sufficient to account for vowel devoicing, there is no need for [-voice] at least for this phenomenon, and [voice] may remain as a privative feature, with specification only for the positive value.

The processes in the VD Database that are critical for the investigation of laryngeal features are those in the segmentally restricted categories. Specifically, it will be shown in this section that in order to account for the variation in consonantal triggers of vowel devoicing, reference to both [-voice] and [+spread glottis] features is required. I will start with arguments based on two case studies from languages with multiple segmentally restricted VD processes involving different sets of consonants. I will then show how the analysis developed to account for these two specific languages in fact also predicts the cross-linguistic distribution of segmental triggers presented previously in 3.3.1.

5.1.1 Evidence from languages with multiple segmentally restricted processes

It should be recalled from the Optimality Theoretic analysis developed in Chapter 4 that the set of voiceless or aspirated consonants involved in a particular segmentally restricted process can inform the laryngeal feature used to account for that process (i.e. the feature targeted by the markedness constraint that motivates devoicing). This is because Segmentally Restricted Vowel Devoicing is analyzed as a form of laryngeal assimilation, whereby a phonological feature associated with a relatively open glottis spreads from a voiceless or aspirated consonant to an adjacent vowel, causing the vowel to devoice. The feature responsible for voicelessness in the vowel must therefore originate from the adjacent consonant, and the larnyngeal feature used in the analysis of a given segmentally restricted process must be able to correctly identify the natural class of consonants to which the process is restricted. Several languages in the VD Database provide particularly interesting case studies in this regard, because they exhibit multiple segmentally restricted processes involving different sets of voiceless consonants. Two such languages are discussed in the following paragraphs, Cheyenne (Algonquian) and Niuafo'ou (Malayo-Polynesian). As will be seen, the presence of multiple segmentally restricted VD processes in these languages supports the involvement of different laryngeal features in triggering these processes.

Cheyenne exhibits three vowel devoicing processes, all of which have been discussed at various points throughout Chapters 3 and 4. Of particular relevance here are the two segmentally restricted processes. The first is a (purely) segmentally restricted process (i.e. prosodically non-restricted), which devoices low tone vowels before voiceless fricatives, as shown in (45) below. Specifically, (45a) shows VD before [h] and [s] in various positions in the word, (45b) shows VD before [ʃ], and (45c) shows VD before [x]. (46) demonstrates that the process in question does not occur before other types of voiceless consonants, including an affricate in (46a) and a stop in (46b).

(45) Cheyenne (purely) Segmentally Restricted VD before voiceless fricatives

a. [m**ḁ**hn**o̥**hts**e̥**stovo̥tse] ‘when you ask him’ (Leman 1981)

b. [nam**e̥**ʃeme] ‘my grandfather’ (Leman 2011)

c. [m**o̥**xéheoʔo] ‘broom’ (Fisher et al. 2017)

(46) No Cheyenne (purely) Segmentally Restricted VD before voiceless stops or affricates (Fisher et al. 2017)

a. [véhp**o**tséhohpe] ‘tea’

b. [óm**o**tóme] ‘air’

The second process in Cheyenne was presented as a case study of Prosodically and Segmentally Restricted VD in Chapter 4. This process devoices vowels before voiceless consonants in the underlying word-final syllable, but as shown in the case study, the devoiced vowels surface in the penultimate syllable due to <e> epenthesis after word-final obstruents. The examples in (47) show that the word-final VD process occurs before a larger set of consonants than the prosodically non-restricted process does. Specifically, (47a) shows that, like the prosodically non-restricted process, word-final VD can occur before fricatives. In (47b), however, we see that word-final VD can also occur before [ts], unlike the prosodically non-restricted process (compare (47b) to (46a)).

(47) Cheyenne Prosodically and Segmentally Restricted VD before any voiceless consonant (Fisher et al. 2017)

a. [hóhko̥x<e>] ‘axe’

b. [ʃéʃenovo̥ts<e>] ‘snake’

It should be recalled from the case study in Chapter 4 that [ts] is an allophone of /t/ in Cheyenne, which surfaces before [e]. In the available materials, we do not find cases of word-final /p/ and /k/, but there is no indication that a vowel in the word-final syllable would fail to devoice before those stops should the context arise. In the absence of counterevidence, the formulation of the second VD process is generalized such that it applies before any voiceless consonant, in contrast the first process, which only applies before voiceless fricatives. To capture this difference between the two processes under consideration, we must invoke two natural classes of consonants, thus necessitating the reference to two different features identifying the relevant sets of consonants: i) voiceless fricatives (to the exclusion of other voiceless consonants) for the first process, and ii) all voiceless consonants for the second.

Niuafo’ou also exhibits three VD processes, but again two are particularly relevant for investigating the nature of the laryngeal features shared with adjacent vowels. As in Cheyenne, it turns out that one of these processes is limited to vowels adjacent to voiceless fricatives, while the other occurs adjacent to any voiceless consonant. The first process was introduced in Chapter 3 as an illustration of (purely) Segmentally Restricted VD triggered by a consonant to the left of the vowel. In this process, (unstressed) high vowels devoice after voiceless fricatives (/s/ and /f/), regardless of what follows them (although, as noted in Chapter 3, like many processes in the VD Database, this one cannot occur in vowel hiatus).

The examples in (48a) and (48b) show this process after a voiceless fricative before a (voiced) nasal, and before a word boundary (i.e. with no following consonant), respectively. In (49), the (unstressed) /i/ in the second syllable does not devoice between a voiceless stop and a nasal, showing that this process is triggered only by voiceless fricatives, not by all voiceless consonants. (All Niuafo'ou data comes from Tsukamoto 1988.)

(48) Niuafo'ou VD after a voiceless fricative

a. [ˌmof**u̥**ˌmofuˈiˑke] 'have earthquakes repeatedly'

b. [ˌmos**i̥**ˈmoˑs**i̥**] 'light rain'

(49) No Niuafo'ou VD after a voiceless stop (and before a voiced consonant)

[ˌmok**i**ˈmoˑki̥] 'break into small pieces'

The second VD process in Niuafo'ou also targets unstressed high vowels and is prosodically non-restricted like the first process; however, its segmental restrictions involve both sides of the vowel. Specifically, this process affects high vowels either between two voiceless consonants or between a voiceless consonant and a word boundary. Although this process is subject to more complex restrictions than the first one, it may nevertheless be considered more general in the sense that it involves a larger set of voiceless consonants than the first process. That is, while the first process occurs only after voiceless fricatives, the second process can be triggered by any type of voiceless consonant (i.e. stops or fricatives). The second process is illustrated between two voiceless stops and between a stop and a word boundary in (50a), between a voiceless stop and a voiceless fricative in (50b), and between a voiceless fricative and a voiceless stop in (50c). There is overlap between the environments of these two processes, so the devoiced vowel preceded by a voiceless fricative and followed by a word boundary in (50c) could be due to either process.

(50) Niuafo'ou VD between two voiceless consonants or a voiceless consonant and word boundary

a. [ˌtukṵˈtuˑkṵ] 'put down for a while'

b. [ˌhauʔaˌliki̥ˈsiˑa] 'attended by chiefs'

c. [ˌtafi̥ˈtaˑfi̥] 'keep sweeping'

When the two VD processes of Niuafo'ou are considered together, two important generalizations emerge regarding the different sets of triggering consonants. First, the contexts in which VD occurs after voiceless stops are limited to a subset of the contexts in which VD occurs after voiceless fricatives. Second, specifically with regard to the second process, we see that voiceless stops and voiceless fricatives to the right of the vowel pattern together as part of the triggering environment. Thus, as in Cheyenne, in order to account for the full range of VD phenomena under consideration, we must be able to separately target i) voiceless fricatives to the exclusion of other voiceless consonants, and ii) the set of all voiceless consonants, including both fricatives and stops.

Returning now to the issue of the laryngeal features involved in VD, it was mentioned in Chapter 4 that works such as Vaux 1998 and Vaux & Miller 2011 have argued that voiceless fricatives, but not voiced fricatives and or other voiceless (unaspirated) consonants, are specified for [+spread glottis]. Following these arguments, which are based on phonological patterns found across a number of languages, we can assume that the processes in Cheyenne and Niuafo'ou involving only voiceless fricatives are restricted to that context because they target a [+spread glottis] feature, which is not present in the representation of the other voiceless consonants in the languages. Thus, Cheyenne VD before voiceless fricatives involves the leftward spreading of [+spread glottis] from a consonant to a vowel, while Niuafo'ou VD after voiceless fricatives involves the rightward spreading of the same feature. Both processes can be analyzed within an Optimality Theory framework following the same approach developed for Comanche in 4.1. That is, a constraint *NonBranching[+SG] requires that the [+spread glottis] feature associated with voiceless fricatives be shared with an adjacent segment, and a higher ranked constraint on the direction of feature spreading (*RightBranch or *LeftBranch) determines the position of VD relative to the consonantal trigger.

We also see in the same languages that voiceless consonants with and without the [+spread glottis] specification pattern together in additional VD processes. This second set of processes cannot be attributed to [+spread glottis] assimilation, since the [+spread glottis] feature crucially distinguishes voiceless fricatives from other voiceless consonants in order to account for the first set of processes. Rather, a different laryngeal feature must be specified to define the set of all voiceless consonants, which is then available to spread voicelessness to adjacent vowels in the relevant contexts. We are thus led to the conclusion that, in addition to [+spread glottis], at least some languages also require the feature specification [-voice]. In particular, this type of analysis is necessary in languages like Cheyenne and Niuafo'ou, where there is evidence of multiple segmentally restricted VD processes involving assimilation of two distinct laryngeal features. It may also be the most effective solution for other VD processes involving both voiceless (unaspirated) stops and fricatives, since voiceless unaspirated stops are assumed not to be specified for [+spread glottis] in general. That is, [+spread glottis] accounts for the feature spreading between voiceless fricatives and adjacent vowels, while [-voice] accounts for the feature spreading between all voiceless consonants and adjacent vowels.

5.1.2 Broader cross-linguistic patterns in the segmental triggers of vowel devoicing

Recall from Chapter 3 that while the sets of triggering consonants vary across languages and processes in the segmentally restricted categories of VD, there is nevertheless an implicational relationship between particular types of triggers. Specifically, it was seen in 3.3.1 that a VD process may be triggered by voiceless fricatives but not (unaspirated) stops (8 processes in the Database), or it may be triggered by voiceless stops and fricatives (30 processes in the Database), but there are no VD processes triggered only by voiceless, unaspirated stops. That is, if a VD process applies adjacent to voiceless stops, it must also apply adjacent to voiceless fricatives, but if a process applies to voiceless fricatives, it does not necessarily also apply to voiceless stops.

The laryngeal features I have proposed to account for Segmentally Restricted VD in Cheyenne and Niuafo'ou provide a straightforward account for the more general cross-linguistic pattern concerning voiceless stops and fricatives. That is, since [+spread glottis] is specified only for voiceless fricatives, a VD process targeting [+spread glottis] will result in the devoicing of vowels adjacent to voiceless fricatives but not adjacent to other consonants. By contrast, since [-voice] is specified for all voiceless consonants a VD process that targets this feature will result in the devoicing of vowels adjacent to both voiceless fricatives and voiceless stops. Crucially, since there is no laryngeal feature that uniquely identifies the class of voiceless, unaspirated stops, we do not encounter VD processes that devoice vowels only adjacent voiceless stops, to the exclusion of voiceless fricatives. Note that in languages with an aspiration contrast in voiceless stops, this analysis also predicts that aspirated stops and voiceless fricatives would pattern together in processes targeting a [+spread glottis] feature, to the exclusion of unaspirated voiceless stops. This seems to be the case for Gangou (Sino-Tibetan, Kerbs 2021), in which vowels devoice after voiceless fricatives, aspirated stops, and affricates, but not after unaspirated voiceless stops, as indicated previously in Table 3.9.

Thus, the phonological approach to VD advanced here not only allows but also requires that there be two laryngeal features available in order to account for the observed patterns of Segmentally Restricted Vowel Devoicing in the VD Database. Specifically, the use of both [+spread glottis] and [-voice] is needed to identify the different sets of consonants that are found to trigger these processes cross-linguistically, and at the same time account for the absence of VD processes that would apply in relation to unattested sets of consonants. Finally, it must be noted that the present analysis of vowel devoicing also contributes to our understanding of the [voice] feature more broadly. That is, since we must refer to the feature specification [-voice], voicing must be considered a binary feature, allowing both "+" and "-" values. This is in contrast to the prior arguments discussed in Chapter 1 in favor of treating [voice] as a privative feature, where only the positive value is available for phonological processes to target. In fact, since [-voice] spreads from obstruents to vowels in these processes, we have evidence that the [-voice] specification must be possible for both obstruents and vowels, despite its unmarked status for the former.

5.2 Positional effects of prosodically strong and weak positions

The next issue to be discussed in this chapter is the status of positional markedness constraints in different types of prosodic positions. As discussed in Chapter 1 and mentioned briefly in Chapter 4, positional markedness effects in strong positions are widely accepted, and well-attested, cross-linguistically. J. Smith (2002) accounts for this type of effect with a schema of positional markedness constraints of the form M/str (where "M" is a general markedness constraint and "str" is a particular strong position to which the markedness constraint is relativized). She moreover restricts the possible markedness constraints to which "M" may refer to ones that enhance perceptual salience, reflecting what she refers to as "phonological augmentation" in strong positions.

I have shown in Section 4.1 that a constraint of the M/str type is indeed necessary to account for the systematic blocking of (purely) Segmentally Restricted Vowel Devoicing in stressed syllables. Since voiceless vowels are less acoustically salient than voiced vowels, and have less recoverable place and pitch information, a positional markedness constraint against voiceless vowels in stressed syllables (e.g., *V[+SG]/ˈσ) ensures the presence of the perceptually more salient voiced vowels in those environments. Given that the M/str constraint in this case blocks processes that are triggered by the segmental environment, the role of prosodic structure is, in effect, a secondary one, with segmental environment playing the primary role.

By contrast, it was seen in Sections 4.2 and 4.3 that prosodic structure plays a primary role in other vowel devoicing processes, specifically in the prosodically restricted categories. What is observed in these cases is that VD is triggered in certain weak prosodic positions. I thus proposed that a second type of positional markedness constraint that makes direct reference to prosodically weak positions is also needed, in order to account for this primary role of prosodic structure seen in some types of vowel devoicing. Whereas Smith's positional markedness constraints have the form M/str, the additional constraints introduced in the previous chapter take the form M/weak. As was seen, the constraints in question reference vowels in domain-final syllables and require them to be associated with a [+spread glottis] or [-voice] feature (e.g., $V[+SG]/]_{\omega}$). Thus, while positional markedness effects in strong positions serve to enhance perceptual salience, those in weak positions are seen in this analysis to have the opposite effect of reducing perceptual salience.

As was noted in Section 4.2, the approach I advocate for challenges a widely held assumption that positional constraints are limited to strong positions. I therefore present in this section a more detailed argument for positional constraints in weak positions, focusing again on domain-final VD. First, I consider the claims made by J. Smith (2002) to justify the use of positional markedness constraints in strong positions rather than positional faithfulness constraints in weak positions, which could produce what may often appear to be the same result. I then briefly review the Optimality Theoretic analysis proposed in Chapter 4 for Wallaga Oromo in the context of Smith's reasoning to show that, in fact, it provides crucial motivation for the use of positional markedness constraints in weak rather than strong positions for this type of phonological process. Finally, I discuss the implications of this approach for our understanding of the relationship between prosodic structure and segmental phonology more broadly.

5.2.1 Markedness in strong positions vs. faithfulness in weak positions

J. Smith (2002) proposes that the restriction of various phonological processes to positions of prosodic prominence is due to markedness constraints relativized to the strong positions in question, which trigger these processes. She also argues against an alternative approach that would use faithfulness constraints relativized to weak positions to account for the same phenomena. She illustrates this argument with an example from Arapaho, where word-initial syllables (i.e. syllables in a strong position) exhibit a stronger requirement for onsets than non-initial syllables. Thus, if a word begins with a vowel, a consonant must be epenthesized to serve as the word-initial onset. In contrast, when there is no consonant to serve as a word-medial onset, epenthesis does not occur, allowing word-medial syllables to surface without onsets. Smith ultimately accounts for this asymmetry between initial and non-initial syllables with an interaction involving i) a positional markedness constraint requiring onsets in the (strong) word-initial syllable, ii) a general faithfulness constraint against epenthesis of segments, and iii) a general markedness constraint requiring (all) syllables to have onsets. These constraints are ranked as follows: Onset/σ_1 >> Dep-seg >> Onset.

Smith also points out, however, that we would arrive at the same result by replacing the positional markedness constraint with a positional faithfulness constraint prohibiting epenthesis in non-initial syllables (a relatively weak position). In this case, the constraints would be ranked as follows: Dep-seg/$\sigma_{\text{non-initial}}$ >> Onset >> Dep-seg. Word-initial epenthesis would therefore be triggered in this approach by the general markedness constraint Onset and blocked in non-initial positions by the higher ranked positional faithfulness constraint. She nevertheless dismisses the alternative analysis not because it cannot account for the data (which it can) but on the grounds that it seems less efficient. That is, in order to identify the (weak) non-initial syllables referred to in the positional faithfulness constraint, one must first identify the (strong) word-initial syllable, and then identify the complement(s) of that position. In fact, the same observation holds for the other phenomena Smith discusses: the weak positions must always be defined relative to a some strong position (e.g., unstressed syllables as the complement of stressed syllables). The strong positions (e.g., word-initial and stressed syllables) can, instead, always be defined directly. While Smith provides a convincing argument in favor of positional constraints referring to strong positions over positional constraints referring to weak positions in the cases that she considers, it can be seen that not all phonological phenomena work in the same way, including prosodically restricted vowel devoicing, examined in the next subsection.

5.2.2 Wallaga Oromo revisited

Returning to the Wallaga Oromo case study developed in Chapters 3 and 4, we can see that Smith's type of reasoning, when applied to Prosodically Restricted VD, ultimately provides a convincing argument for markedness constraints that refer directly to prosodically weak positions. That is, the weak position must be specifically targeted by the markedness constraint, rather than identified merely as the "opposite" or "complement" of a strong position.

As was seen previously, Wallaga Oromo exhibits devoicing of word-final vowels regardless of what segment precedes them. In Chapter 4, I accounted for this pattern with a positional markedness constraint that requires vowels to be associated with a [+spread glottis] feature in word-final position: $V[+SG]/]_{\omega}$. This constraint outranks a faithfulness constraint against laryngeal feature insertion, Dep[Lar], permitting a [+spread glottis] feature to be inserted onto a word-final vowel if there is no adjacent [+spread glottis] consonant to share this feature with the vowel. Of course, the positional markedness constraint, $V[+SG]/]_\omega$ also outranks a general markedness constraint against voiceless vowels, *V[+SG], which prevents voiceless vowels from appearing elsewhere in the language.

If we attempt to reanalyze the Wallaga Oromo VD phenomenon following Smith's approach, with a positional markedness constraint blocking VD in prosodically strong positions instead, we arrive at a less desirable analysis, involving more, rather than less, complexity. Specifically, in order to identify the positions in which VD does not occur in Wallaga Oromo, we must first identify the weak position (i.e. word-final). Only then is it possible to identify the complementary strong positions that prohibit VD (non-word-final). In this way, the strong and weak positions involved in domain-final vowel devoicing seem to be in a fundamentally different type of relationship to one another than the strong and weak positions considered in J. Smith 2002.

Further examination of the specific set of constraints needed for the alternative analysis of Wallaga Oromo word-final VD presents a second problem, which turns out to be more serious than the issue of simplicity. An analysis that relies on positional constraints in strong rather than weak positions must involve a general markedness constraint requiring vowels to be voiceless, such as V[+SG], and a positional markedness constraint prohibiting voiceless vowels in all non-word-final environments, such as $*V[+SG]/\_\_ ...]\omega$. A ranking of the positional markedness constraint over the general markedness constraint ($*V[+SG]/\_\_ ...]\omega >> V[+SG]$) has the desired effect of triggering VD only in word-final vowels without direct reference to a weak position. Crucially, however, since vowels are typically voiced cross-linguistically, we must also assume that all languages include another universal markedness constraint with the opposite preference of V[+SG]: *V[+SG]. This type of constraint was seen in the previous analyses of Comanche and Cheyenne in Chapter 4 as well. The interaction of all three constraints is shown in the tableau in (51), producing the form [narḁ] 'brow.'

(51) Wallaga Oromo /nara/ → [narḁ] 'brow' without direct reference to a weak position

/nara/	*V[+SG]/__ ...]ω	V[+SG]	*V[+SG]
a. nara		**!	
☞ b. narḁ		*	*
c. nḁrḁ	*!		**

While (51) provides the correct outcome, the analysis involves a more broadly undesirable, or problematic ranking of the constraints that require and prohibit the association of [+spread glottis] with vowels (yielding voiceless and voiced vowels, respectively). That is, V[+SG] must outrank *V[+SG]. Crucially, this suggests that voiceless vowels are more highly favored than voiced vowels. This is directly contrary to the widely attested and accepted cross-linguistic pattern, in which voiced vowels are unmarked and voiceless vowels are marked.

Thus, while an approach to word-final VD that uses positional constraints in strong rather than weak positions could be developed and would conform to previous attempts to reduce all positional effects to constraints referencing strong positions, it would lead to complications when considered from a broader phonological perspective. Not only is it less insightful and less efficient than the approach that directly specifies weak positions as the targets of vowel devoicing, it is also fundamentally inconsistent with the established markedness relation between voiced and voiceless vowels.

5.2.3 Broader implications for the interactions between prosodic structure and segmental phonology

In sum, we see that prosodic structure can have two major roles in relation to vowel devoicing, resulting from essentially opposite preferences regarding the segmental material in strong vs. weak positions. In the case of (purely) segmentally restricted processes, vowel devoicing is triggered by the vowel's immediate segmental environment. In this type of process, prosodic structure may only have a secondary effect, serving to block VD in strong prosodic positions, especially stressed syllables. This ensures that the vowels are voiced, and thus more acoustically and perceptually salient, in strong positions. The opposite effect is observed in the prosodically restricted VD processes, where prosodic structure has a primary role, that of triggering vowel devoicing in specific weak positions. In this way, the less acoustically and perceptually salient voiceless vowels are actually preferred over voiced vowels in certain positions. In order to account for both types of preferences, as well as the different roles that prosodic structure may play (triggering vs. blocking), we need positional markedness constraints in both strong and weak positions. The constraints in strong positions block VD, whereas those in weak positions trigger VD.

Considering the broader implications of the proposed analysis, it was noted that the introduction of constraints relativized to weak prosodic positions differs from previous approaches that aim to attribute all positional effects to constraints relativized to strong positions. As such, it offers new insight into, and a deeper understanding of, the relationship between prosodic structure and segmental phonology more broadly. As was seen in the analysis of Wallaga Oromo, the inclusion of positional constraints in weak positions not only results in a simpler account of the facts of domain-final VD, but it also crucially allows us to avoid a constraint ranking that would suggest a contradiction of the cross-linguistic preference for voiced, rather than voiceless, vowels. Weak position constraints are thus justified, in this case, on the grounds of both simplicity and consistency with our broader understanding of the relative markedness of voiced vs. voiceless vowels. Finally, the inclusion of both strong and weak positional markedness constraints directly encodes the more general insight that while prosodically strong positions favor acoustically and perceptually salient elements, weak positions favor less salient ones, and that, crucially, neither effect can - or should - be reduced to an indirect consequence of the other.

5.3 Prosodic and segmental restrictions in domain-final VD: the role of domain generalization

The final issue to be discussed in this chapter is the relationship between prosodic and segmental restrictions, specifically with regard to domain-final vowel devoicing. It was demonstrated in Chapter 4 that Optimality Theory offers an insightful unified treatment of (purely) Prosodically Restricted VD and Prosodically and Segmentally Restricted VD, with both categories of devoicing attributed to the same set of constraints. In this analysis, all that is needed to distinguish between presence or absence of segmental restrictions on a prosodically restricted process is a difference in ranking between two key constraints: a positional markedness constraint requiring voiceless vowels in a prosodically weak position, and a faithfulness constraint prohibiting laryngeal feature insertion, Dep[Lar]. As was just noted in Section 5.2, the prosodic restriction is treated as the primary one for both prosodically restricted types of VD. The segmental restriction then serves a secondary role, in some cases, emerging from an interaction between the positional markedness constraint and the independent faithfulness constraint. This section examines in greater detail the relationship between prosodic and segmental restrictions on domain-final VD, and relates it to the role of different sized domains. Specifically, I consider the phonetic grounding of domain-final VD and its limitations in 5.3.1, the insights provided by domain generalization in 5.3.2, and finally the implications of the proposed analysis for some finer-grained patterns observed in the VD Database in 5.3.3.

5.3.1 Phonetic grounding of domain-final vowel devoicing

Domain-final vowel devoicing has often been considered a phonetically grounded phenomenon. Specifically, previous works such as Dauer 1980, Gordon 1998, and C. L. Smith 2003 attribute it to either of two phonetic sources: i) decreasing subglottal air pressure over a long stream of speech, the lowest point coinciding with the end of the domain in question, or ii) the anticipatory opening of the glottis before a pause, also coinciding with the end of a domain. When these phonetic factors are considered more closely, however, it can be seen that they apply straightforwardly only to one subtype of prosodically restricted VD in the Database: the segmentally non-restricted domain-final processes that apply in relation to a relatively large prosodic domain (i.e. in phrase- or utterance-final positions), where a decrease of subglottal pressure and/or the anticipation of a pause can be expected. It should be recalled from Chapter 3 that this dissertation does not distinguish between different sized phrase or utterance domains, but rather refers to all processes that apply at the end of a domain larger than the word as "large domain-final." This is the category that can be understood as phonetically grounded. Similar phonetic pressures are not expected at the ends of smaller domains, although it was shown in Chapter 3 that prosodically restricted VD is also well-attested at the end of the (smaller) word domain. Moreover, the general phonetic properties that motivate large domain-final VD processes make no reference to particular segments in proximity to vowels, failing to predict the language-specific interactions with laryngeal properties of adjacent consonants (e.g., voicelessness, aspiration) that characterize the prosodically and segmentally restricted category of VD, which is also well-attested cross-linguistically.

At first glance, it therefore seems problematic that domain-final vowel devoicing can apply word-finally in addition to phrase- and utterance-finally, and that it includes processes with segmental restrictions, if this broad category of VD is indeed motivated by the phonetic grounding considerations just mentioned. The rest of this section provides more detailed consideration of domain-final VD at different sized domains, leading to a deeper understanding of both the variation observed in these processes and the role of phonetics. This provides the possibility of integrating all domain-final processes into a unified account that ultimately does derive from, but is not always synchronically dependent on, the same sources of phonetic grounding.

5.3.2 Domain Generalization

I propose that the key to understanding both the limitations of phonetic grounding for small domain-final processes and the role of segmental restrictions in some instances of domain-final vowel devoicing lies in a diachronic mechanism referred to as domain generalization (e.g., Myers & Padgett 2014), previously also referred to as "boundary narrowing," (e.g., L. Hyman 1978). In particular, the concept of domain generalization (DG) has been proposed as the mechanism responsible for word-final phonological processes that are not themselves phonetically grounded, but which could be seen as grounded if they were instead restricted to phrase- or utterance-final positions. Specifically, DG results from the phonologization over time of what was originally a phonetically grounded utterance-final process. Once phonologized, the process no longer relies on the original phonetic grounding, and thus may extend to other, smaller, prosodic domains. DG has been effectively invoked to explain to a number of word-final phenomena, including obstruent devoicing (see Myers & Padgett 2014 and references therein) as well as various tonal and accentual phenomena (e.g., Becker 1977; L. Hyman 1978; Zec & Zsiga 2022). The application to obstruent devoicing is particularly relevant in this case, since it is associated with the same phonetic motivations provided for domain-final vowel devoicing (i.e. decreasing subglottal pressure and anticipation of a pause).

Word-final vowel devoicing without segmental restrictions

Given the similarity between the phonetic motivations for domain-final vowel and domain-final obstruent devoicing, the application of the concept of domain generalization to word-final (segmentally non-restricted) VD becomes quite straightforward. That is, while vowel devoicing is not phonetically grounded in word-final position, it is related to a phonetically grounded process at the end of a larger domain in the following way. If the manifestations of the aerodynamic and articulatory pressures at the ends of large domains become phonologized, this means that they are no longer dependent on the original context, and can extend to other, similar phonological positions without the original phonetic pressures. Thus, when we observe VD in word-final position, we may interpret this as evidence that an originally phonetically-grounded VD process has become phonologized and subsequently generalized to the smaller domain.

In fact, the effect of the phonologization of VD can be seen transparently in the constraint-based analysis developed in Chapter 4. While domain-final VD may originate as a purely aerodynamic or phonetic phenomenon at the ends of phrases and/or utterances, it becomes relevant for the phonological system of a language only once it is phonologized, as reflected in a positional markedness constraint that requires vowels to be voiceless phrase-finally (e.g., V[+SG]/$]_{\phi}$). When a similar type of constraint is then found to target word-final vowels, instead of phrase-final ones, we have evidence of the extension of this phonologized process to a smaller prosodic domain. This is precisely what was seen in the analyses of Wallaga Oromo and Cheyenne in Sections 4.2 and 4.3, respectively. Thus, we may now understand the word-final constraints proposed for these languages (i.e. V[+SG]/$]_{\omega}$ and V[-voice]/$\sigma]_{\omega}$) as the result of domain generalization of a very basic, phonetically motivated process widely observed cross-linguistically at the ends of large prosodic domains.

Segmental restrictions on domain-final vowel devoicing

The insight regarding phonologization of domain-final vowel devoicing now also allows us to better understand the segmental restrictions on these processes that are found in some languages. Once a phonetic process of domain-final VD is phonologized, it becomes available to interact with other aspects of the phonological system of a language in more complex ways. As such, it may become subject to additional language-specific restrictions that are no longer directly connected to the original phonetic source of the process. In particular, this yields in some cases segmental restrictions on domain-final VD that are not themselves phonetically grounded, but that are possible outcomes of phonology. This situation resembles in certain ways the domain generalization of tonal retraction in dialects of Serbian discussed in Zec & Zsiga 2022. In that case, the authors propose that the phenomenon in question involves reanalysis of a phrase boundary effect to a word-level stress effect once it loses its original phrase-final motivation.

Again, the constraint-based analysis allows us to interpret the implications of domain generalization in vowel devoicing in an insightful way, using a positional markedness constraint to represent the phonologized VD effect. Recall that the positional markedness constraint (e.g., V[+SG]/$]_\omega$ or V[-voice]/$\sigma]_\omega$) refers only to a vowel in a particular prosodic position. It does not include any information about the local segmental environment, just as the original domain-final phonetic effect was independent of the segmental environment. Rather, different roles of the segmental environment in domain-final VD arise from different rankings of this constraint relative to other constraints in a given language.

Specifically, as was illustrated in the Cheyenne case study in Chapter 4, segmental restrictions emerge when the positional markedness constraint is ranked below the faithfulness constraint Dep[Lar], which prevents the insertion of a laryngeal feature. This ranking ensures that the positional markedness constraint is satisfied only when the necessary laryngeal feature can spread from a neighboring consonant, as opposed to being inserted on the vowel in question. (See the tableaux in Section 4.3.) Crucially, this account makes the prediction that segmental restrictions on domain-final VD are only possible for processes that have been phonologized, not for processes that are still at the phonetic stage.

Thus, the Optimality Theoretic approach developed in this dissertation not only accounts for the different types of domain-final VD found cross-linguistically, but it also transparently shows the pathway by which an originally phonetically grounded domain-final effect may work its way into and then through the phonological system of a language. This in turn reflects different stages of domain generalization and the related language-specific interactions that otherwise obscure the phonetic grounding of some Prosodically Restricted VD.

5.3.3 Domain-final vowel devoicing across languages in the VD Database

The domain generalization approach to Prosodically Restricted Vowel Devoicing goes beyond accounting for the existence of seemingly phonetically ungrounded segmental restrictions on some of these processes. It also provides new insight into an additional pattern found in the VD Database (originally presented in 3.3.2), concerning the role of segmental restrictions in domain-final processes across different sized prosodic domains. To review those findings, two tables from Chapter 3 are repeated below. The first shows the distribution of domain-final processes both across segmentally restricted and non-restricted categories and across different sized prosodic domains. The second lists the languages with processes in each of these categories.

	Word-final		**Large domain-final**	
	number	percent	number	percent
Segmentally Restricted	7	50%	1	6.7%
Segmentally Non-Restricted	7	50%	14	93.3%

Table 5.1: Counts and percentages of segmentally restricted vs. segmentally non-restricted domain-final devoicing by prosodic domain.

	Word-final	**Large domain-final**
Segmentally Restricted	Andean Spanish, Brazilian Portuguese, Cheyenne, Ecuadorian Spanish, Japanese, Northern Paiute, Rapa Nui	Zihuateutla Totonac
Segmentally Non-Restricted	Acoma, Borana Oromo, Orma, Southern Paiute, Tohono O'odham, Wallaga Oromo, Woleaian	Blackfoot, Chama, Cheyenne, Comanche, European French, Fox, Ik, Iquito, Tümpisa Shoshone, Malagasy, Nyangumarta, Oneida, Pisaflores Tepehua, Turkana

Table 5.2: Languages with segmentally restricted vs. segmentally non-restricted domain-final devoicing by prosodic domain.

While these tables show that there are roughly equal numbers of word-final and larger domain-final processes (14 in one category, 15 in the other), they also show that the role of segmental restrictions is not equally distributed. Within the word-final category, segmentally restricted and non-restricted processes are equally likely (7 in each category). By contrast, the large domain-final processes are almost always segmentally non-restricted, with the process in Zihuateutla Totonac constituting the only exception.

Recalling the discussion of domain generalization in the previous subsection, we now have an explanation for the asymmetrical distribution of segmental restrictions across small and large domain-final processes. I have proposed that word-final vowel devoicing must be the result of phonologization and subsequent generalization of a phonetically grounded, segmentally non-restricted version of domain-final devoicing. This phonologization allows for new interactions with other aspects of a language's phonological system. Within Optimality Theory, this means that word-final VD arises as the outcome of constraint interactions, which, depending on language-specific rankings, may or may not introduce additional segmental restrictions. Specifically, I have shown that a ranking of Dep[Lar] >> positional markedness results in segmentally restricted VD, whereas the reverse ranking results in segmentally non-restricted VD. Assuming that both ranking options are equally likely, we should find roughly equal numbers of word-final VD processes with and without segmental restrictions, just as we do in the VD Database.

In contrast, vowel devoicing observed at the ends of larger domains is phonetically grounded, attributed to decreasing subglottal pressure and/or anticipation of a pause. As such, its presence is not dependent on the local segmental environment. I therefore proposed that purely phonetic domain-final devoicing can only be segmentally non-restricted. This explains why segmental restrictions on large domain-final processes are largely unattested. In fact, it was noted in the previous subsection that the domain generalization account of vowel devoicing makes this exact prediction, namely that segmental restrictions would only be found in fully phonologized versions of the process, where VD results from constraint interactions. It should be possible, however, for some small subset of large domain-final processes to be phonologized, and therefore at an intermediate stage of domain generalization. (In fact, domain generalization assumes that all word-final processes have passed through a phonological phrase-final stage.) It is only within this subset of large domain-final processes that have been phonologized that segmental restrictions should be possible. From this perspective, domain-final VD in Zihuateutla Totonac is one such process.

5.4 Discussion

This chapter has examined in greater detail three key findings that emerged from the Vowel Devoicing Database, typology, and constraint-based analysis developed in previous chapters of this dissertation, each of which has broader implications for a larger issue in phonological theory. These issues include the nature of laryngeal representations in Feature Theory, the ways in which prosodic structure and segmental phonology interact, and the roles of phonetic grounding and domain generalization in the distribution of phonological processes.

With regard to laryngeal features, I demonstrated that the different sets of segmental triggers seen in the VD Database require the use of both [-voice] and [spread glottis] features in the representations of voiceless vowels across languages (Section 5.1). [-voice] is needed for processes involving all voiceless consonants, whereas [+spread glottis] is needed for processes that involve voiceless fricatives but not unaspirated voiceless stops. In fact, case studies of Cheyenne and Niuafo'ou have shown that these two different features are needed to account for not only the variation in segmental triggers observed cross-linguistically, but also, in some cases, the occurrence of multiple segmentally restricted processes in a single language. This analysis, in turn, provides evidence in support of a binary, as opposed to privative, [voice] feature within the broader context of Feature Theory. Since the dominant arguments in favor of privative [voice] have been based primarily on obstruent phonology (see discussion in Section 1.2), the insights obtained by vowel devoicing demonstrate the value of incorporating evidence from a wide range of phenomena and, more specifically, of considering vowel devoicing from not only a phonetic perspective but also a phonological one.

With regard to interactions between prosodic structure and segmental phonology, it was demonstrated in Section 5.2 that two types of positional markedness constraints are necessary to account for the full range of vowel devoicing processes identified in this dissertation. One type reflects the preference for perceptually salient segments (i.e. voiced vowels) in strong positions. The other type reflects the opposite preference for less salient segments (i.e. voiceless vowels) in weak positions. It is not feasible to limit the positional markedness constraints in our theory to those that reference strong positions. Moreover, it was seen that positional constraints may play different roles in a segmental process. In the case of vowel devoicing, the effect may be that of blocking a segmental process (in strong positions), or triggering a segmental process (in weak positions). Ultimately, the perspective gained by including weak position constraints in the analysis of vowel devoicing suggests that further investigation of other types of phenomena may also be more insightfully accounted for by distinguishing effects in prosodically strong vs. weak positions.

Finally, the similarities and differences between domain-final vowel devoicing processes in larger and smaller prosodic domains were shown to be directly accounted for in terms of domain generalization (Section 5.3). This expands the potential role of domain generalization within phonological systems, and offers additional insight into both the role of phonetic grounding and interactions between prosodic structure and segmental phonology in domain-final VD. In particular, it was seen that phonetically grounded domain-final VD exhibits one type of interaction between prosodic structure and segmental phonology, with prosodic position influencing a segmental property of a vowel. Then, once this process becomes phonologized and extended to smaller domains via domain generalization, there is the possibility for a second type of interaction between prosodic structure and segmental phonology to emerge, with prosodic and segmental environment conditioning a segmental process together. Interestingly, this account also provides a new insight into domain generalization itself. While most examples involve phonologization and generalization of a single process (see Myers & Padgett 2014 for discussion of various cases of DG), the account of domain-final VD in this chapter has shown that it must be a markedness constraint that is generalized instead. Crucially, this may produce different types of processes depending on language-specific constraint rankings (e.g., feature spreading vs. feature insertion in the case of domain-final VD). In this way, the type of formal analysis afforded by Optimality Theory not only simply, but also insightfully, addresses the vowel devoicing issues at hand, and suggests meaningful extensions to other types of phonological phenomena.

CHAPTER 6

CONCLUSION

This dissertation has presented a systematic phonological analysis and typology of vowel devoicing patterns across the world's languages based on a survey of 70 processes in 53 languages. This work differs fundamentally from the majority of previous investigations of vowel devoicing, which have focused instead on the phonetic realizations and articulatory mechanisms of the phenomenon. As discussed in Chapter 1, vowel devoicing is found to interact in critical ways with other phonological processes in a given language, which indicates that it must take place within the phonology, at least in those cases. Thus, in order to develop a thorough understanding of vowel devoicing, it is necessary to go beyond the phonetic mechanisms involved, and also examine the phonological mechanisms of the phenomenon. To address the dearth of phonological research on VD, the present investigation has provided i) the results of a cross-linguistic survey of vowel devoicing processes that considers not only the processes themselves but also how they fit into the larger phonological systems of the languages in which they are found (see VD Database in Appendices A-E), ii) a typological model comprising the different types of VD processes seen in the VD Database, iii) a formal (Optimality Theory) analysis of the categories found in the typology, and iv) a discussion of the broader implications for phonological theory that emerge from the phonological approach to vowel devoicing.

In this concluding chapter, I first review the specific contributions the dissertation makes to our understanding of vowel devoicing itself and its implications for broader phonological issues, the latter following from the phonological approach to VD developed here. I then briefly identify several directions for future research suggested by the findings of this dissertation.

6.1 Summary and contributions of this dissertation

Chapters 1 and 2 of this dissertation provided the motivation and crucial background for the present investigation. The major trends, as well as the lacunae, in the vowel devoicing literature were introduced, demonstrating, in turn, the need for a phonological approach to the phenomenon, and indicating several larger theoretical issues that a phonological understanding of VD can inform. Chapter 3 then presented the cross-linguistic survey of VD carried out as the basis for this dissertation. The resulting VD Database was also introduced, not only a means of systematizing the findings of the survey, but also as a basic resource that may serve for future investigations of VD.

In addition to presenting the empirical basis for the dissertation, Chapter 3 developed a typological model of vowel devoicing accounting for the patterns that emerged from the VD Database. This model classifies the VD processes in relation to the different roles of played by prosodic and segmental conditioning factors. Specifically, the prosodic and segmental dimensions of vowel devoicing were incorporated in the typology as two distinct, but in certain cases interacting, parameters, yielding three categories of processes found in the VD Database: i) (purely) Segmentally Restricted Vowel Devoicing, ii) (purely) Prosodically Restricted Vowel Devoicing, and iii) Prosodically and Segmentally Restricted Vowel Devoicing. This classification system thus revealed two basic requirements that must be met by a complete phonological account of VD. First, it must include distinct prosodic and segmental components, given that some processes are conditioned by only one of the two parameters (i.e. the processes in first two categories listed above). Second, it must provide a means for the two parameters to interact in some cases, since other processes are conditioned by a combination of segmental and prosodic factors (i.e. the third category above).

Chapter 4 then presented a phonological analysis of vowel devoicing within the framework of Optimality Theory, informed by the typology from Chapter 3. This analysis demonstrated that while some types of variation in VD processes across languages require distinct types of analysis (involving different sets of constraints), others can be reduced to differences in ranking of the same set of constraints. This in turn allowed for the unification of two of the original three categories of VD identified in Chapter 3.

Specifically, I proposed that it was possible to view the two independent mechanisms (prosodic and segmental) responsible for VD as two types of markedness constraints. (Purely) Segmentally Restricted Vowel Devoicing was attributed to a markedness constraint that requires a specific laryngeal feature typically associated with voiceless or aspirated consonants to be shared with an adjacent segment in the output. This causes vowels to devoice by assimilating to adjacent voiceless or aspirated consonants. (Purely) Prosodically Restricted Vowel Devoicing, by contrast, was attributed to a positional markedness constraint that requires vowels to be associated with a specific laryngeal feature in a particular prosodically weak position. I then demonstrated that the third category of vowel devoicing, in which the two parameters appear to interact (i.e. Prosodically and Segmentally Restricted VD), is most insightfully viewed from this formal perspective as a variant of the basic prosodically restricted category, resulting from a lower ranking of the same type of positional markedness constraint. That is, when the positional markedness constraint is ranked below a faithfulness constraint Dep[Lar], which prohibits the insertion of laryngeal features, vowel devoicing can only occur when the necessary laryngeal feature is available to spread from an adjacent voiceless or aspirated consonant, thus constituting the segmental restriction. The reverse ranking yields (purely) Prosodically Restricted VD, since vowel devoicing can occur in this case even if the necessary laryngeal feature must be inserted (i.e. if there is no adjacent segment with the relevant feature).

Finally, Chapter 5 examined in greater detail several findings and insights from the VD Database, typology, and Optimality Theoretic analysis, each of which has broader implications for phonological theory. First, I argued that both [+spread glottis] and [-voice] feature specifications are needed to account for the full range of vowel devoicing phenomena. This argument was based on two types of phonological evidence. One type of evidence came from the observation that some languages (seen in case studies of Cheyenne and Niuafo'ou) exhibit multiple segmentally restricted VD processes, each involving different sets of voiceless segments that must be identified by different laryngeal features. The other type of evidence came from broader patterns in the VD Database involving the sets of voiceless consonants that do and do not trigger vowel devoicing cross-linguistically. In this case, it was shown that the combination of [+spread glottis] and [-voice] is necessary to account both for the variation in triggering consonants seen cross-linguistically and for the absence of unattested sets of triggering consonants. Ultimately, this analysis was also shown to have more far-reaching implications for Feature Theory. In particular, since a "-" specification of [voice] is needed to account for some vowel devoicing processes, it requires that [voice] be a binary feature, thus introducing a fundamental challenge to arguments that laryngeal features should be privative (e.g., Brown 2016; Cho 1990; Lombardi 1991, 1995; Mester & Itô 1989), and supporting those in favor of binary features instead (e.g., W. G. Bennett & Rose 2017).

Second, I considered the role of both strong and weak prosodic positions in vowel devoicing and argued that both can have their own direct influence on segmental phonology. This was attributed to two different types of positional markedness constraints. The positional constraints in strong positions block VD processes that are triggered by independent conditioning factors, whereas positional constraints in weak positions trigger VD processes. The effect of strong positions can be understood (along the lines of J. Smith 2002) as a means of ensuring perceptual salience in prominent positions and are consistent with previous approaches to representing prosodic prominence effects on segmental phonology within Optimality Theory. The innovation that emerges from this investigation of vowel devoicing pertains to positional constraints in weak positions.

While previous work has attempted to account for asymmetrical distributions of segmental phenomena across strong and weak positions with constraints relativized only to strong positions, examination of Prosodically Restricted Vowel Devoicing revealed that this does not always yield a tenable analysis. Rather, attempts to avoid direct reference to weak positions in analysis of these phenomena were shown to be less elegant from a formal perspective and to require constraint rankings that are inconsistent with well-established cross-linguistic markedness patterns. Thus, it was demonstrated that the role of weak positions in VD cannot simply be reduced to indirect consequences of the strong position effects, but rather require the implementation of independent weak position constraints in certain cases. Whereas strong position constraints protect or enhance perceptual salience, these weak position constraints serve to reduce perceptual salience in non-prominent positions.

Thus, the generalizations that emerge with regard to prosodic structure and vowel devoicing are that i) the effect of strong positions is to block vowel devoicing processes, while the effect of weak positions is to trigger these processes, and ii) these can be attributed to a general preference for greater perceptual salience in strong positions and the opposite preference in weak positions. This, in turn, suggests the possibility that direct reference to weak positions may offer more insightful analyses of other types of phonological phenomena, even if it is possible to formulate them in terms of just strong positions. In this case, our broader understanding of phonological systems across languages may outweigh the apparent economy achieved by reducing all positional effects to formulations involving solely strong positions.

Third, I considered the role of phonetic grounding, in particular, in relation to the domain-final vowel devoicing processes in the VD Database. At first glance, several variants of these processes appear somewhat idiosyncratic; however, I demonstrated that analyzing them in terms of the mechanism of domain generalization leads to additional insights regarding the observed surface patterns. This perspective, moreover, supports the Optimality Theoretic analysis developed in Chapter 4 that treats all cases of domain-final VD in a unified way.

Specifically, it was pointed out that the segmentally non-restricted large (phrase- or utterance) domain-final VD processes are the only ones that can be considered phonetically grounded either in terms of aerodynamic pressures that make voicing more difficult to produce at the ends of long streams of speech, or anticipatory glottal opening before a pause (e.g., explanations proposed in Dauer 1980; Gordon 1998; C. L. Smith 2003). Such phonetic effects, however, cannot explain the other well-attested cases of domain-final vowel devoicing in the VD Database, specifically the word-final processes that are either segmentally restricted or segmentally non-restricted. In many word-final positions, the phonetic pressures associated with larger domain devoicing are not present, and furthermore, there is nothing in the phonetic pressures that would predict the observed language-specific interactions with the local segmental environment.

I then introduced domain generalization (see Myers & Padgett 2014 for application of this concept to other domain-final phenomena) as a means of understanding how the word-final VD processes with and without segmental restrictions could have originated as phonetically grounded phrase- or utterance-final processes, and subsequently made their way to smaller domains. That is, it was proposed that domain-final vowel devoicing starts as a purely phonetic effect at the ends of large phrases or utterances, without reference to the local segmental environment. When this effect becomes phonologized, it is then free to generalize to other contexts in which the original phonetic pressures are no longer present. Thus, when VD is observed at the end of the word domain, the original phonetic process is no longer what determines its application, but rather it is determined by the conditions resulting from phonologization, as well as any additional conditions that develop from interactions with the rest of the phonological system of the language in question. It is also these language-specific phonological interactions that yield segmental restrictions in some cases.

The analysis of domain-final VD from the perspective of domain generalization also suggests further consideration of the domain generalization mechanism itself. While most examples of domain generalization involve phonologization and generalization of a single process, I proposed in Chapter 5 that domain generalization may additionally, or instead, apply to a markedness constraint rather than a specific process. In the case of domain-final VD, the surface preference for domain-final voiceless vowels is phonologized, which I formalize as a positional markedness constraint. It is then this surface preference or markedness constraint that gets generalized, not a particular process or rule. This approach allows us to predict different types of surface patterns depending on language-specific rankings of the relevant constraints (e.g., feature insertion vs. feature spreading, in the case of domain-final VD). The outcome in a given language will thus bear more or less resemblance to the original phonetically motivated process depending on the constraints and their rankings operational in that language.

6.2 Directions for future research

The findings, analyses, and broader implications of this dissertation, summarized above, address a number of gaps in the vowel devoicing literature, but they also suggest a number of interesting areas for future research. First, in the context of laryngeal representations, I have provided phonological evidence that both [+spread glottis] and [-voice] features are needed in order to account for VD in a broad range of languages. I also identified several languages in which different instances of devoiced vowels must be analyzed with different laryngeal features (i.e. devoiced vowels adjacent to voiceless fricatives vs. stops in Cheyenne and Niuafo'ou). Such cases suggest an approach to testing the mapping relationships between phonologically motivated laryngeal features and their phonetic (acoustic or articulatory) realizations in a principled way. That is, instead of simply using the phonetic properties of devoiced vowels to justify the use of one particular laryngeal representation over another, we may now systematically investigate and verify the mappings or phonetic outputs by comparing devoiced vowels that are predicted for phonological reasons to bear different laryngeal features. For instance, we may test the assumption that [+spread glottis] should be associated with a larger glottal opening than [-voice] (e.g., Tsuchida 1997 and references therein) as a specific prediction by comparing the realization of these different features in the same type of segment.

Second, this dissertation has identified a type of interaction between prosodic structure and segmental phonology that requires direct reference to a prosodically weak position, specifically, a domain-final syllable. The question remains, however, whether other types of weak positions may also exhibit similar effects on segmental phonology. As discussed in Chapter 1, two sources of prosodic strength and weakness are i) positions relative to heads of prosodic constituents, and ii) positions relative to edges of prosodic constituents. Domain-final environments are a weak edge position, so it would be especially important to additionally consider weak positions resulting from headedness instead (e.g., the non-head syllable of a foot). Possible cases may be found in Lezgian (Chitoran & Babaliyeva 2007; Chitoran & Iskarous 2008) and Ecuadorian Spanish (Lipski 1990), mentioned briefly in Chapter 3, where VD appears to be restricted to the immediately pretonic syllable. Since these processes do not occur in other unstressed syllables, their distribution may point to a difference between the non-head syllable of a foot and other unstressed syllables that are not footed in the same word. Both processes are included in the VD Database, but unfortunately there is insufficient data in the prior literature for a thorough case study of either process in the context of this dissertation. Future language-specific investigation of these two processes could contribute to our further understanding of the role of non-head positions in segmental phonology.

Finally, I noted in Chapter 5, and earlier in this concluding chapter, that domain generalization of phrase-final vowel devoicing appears to involve a surface preference for voiceless vowels at the right edge of prosodic constituents. I represented this as a positional markedness constraint, rather than a specific process, and showed how different language-specific rankings of this positional markedness constraint can yield different processes. I also pointed out that one of these processes reflects an additional interaction between prosodic structure and segmental phonology, when the constraint ranking requires a feature to spread from an adjacent consonant (rather than be inserted) in order to satisfy the markedness constraint. This is in contrast to the more common examples of domain generalization in the literature, in which essentially the same process is generalized from larger to smaller prosodic domains. Future work should therefore explore other phonological phenomena in which we may be able to distinguish between domain generalization pertaining to processes and constraints.

APPENDIX A

VOWEL DEVOICING DATABASE: LANGUAGE INFORMATION

The contents of the Vowel Devoicing Database are presented here and in the four subsequent appendices. The two tables below provide information on each language included in the Database. The first lists the languages, their language families, the geographic regions in which they are spoken, and the main sources on which my descriptions of vowel devoicing are based. The second lists the languages along with relevant phonological information: the number of vowel devoicing processes they contribute to the Database, presence/absence of stress, presence/absence of tone, and any relevant notes about the phonology of these languages or phonological issues with the sources. The tables in the remaining appendices present information for each VD process.

Language	**Family**	**Geographic region**	**Main sources**
Acoma	Keresan	N. America	Miller 1965; Cho 1993
Ainu	Ainu	Japan	Shiraishi 2003
Andean Spanish	Romance	Peru	Delforge 2008
Ashéninka	Maipurean	Peru	Payne 1990; Mihas 2010
Big Smoky Valley Shoshone	Numic	N. America	Crapo 1976
Blackfoot	Algonquian	N. America	Gick et al. 2012; Frantz 2017
Borana Oromo	Cushitic	Ethiopia, Northern Kenya	Voigt 1985
Brazilian Portuguese	Romance	Brazil	Meneses & Albano 2015; J. Walker & Mendes 2019
Cayuga	N. Iroquian	N. America	Foster 1982; Doherty 1993
Chama	Panoan	Bolivia	Firestone 1955
Cheyenne	Algonquian	N. America	Leman & Rhodes 1978; Leman 1981; Leman 2011
Chickasaw	Muskogean	N. America	Gordon 2004
Cochabambino Spanish	Romance	Bolivia	Sessarego 2012
Comanche	Uto-Aztecan	N. America	Cho 1993; Robinson and Armagost (2012)
Ecuadorian Spanish	Romance	Ecuador	Lipski 1990

European French	Romance	Europe	Fagyal & Moisset 1999; C. L. Smith 2003; Torreira & Ernestus 2010; Bayles 2016
Fox	Algonquian	N. America	Goddard 1991
Gangou	Sino-Tibetan	China	Kerbs 2021
Greek	Attic	Greece	Dauer 1980
Hrusso Aka	Sino-Tibetan	India	D'Souza 2018
Ik	Nilo-Saharan	Uganda	Schrock 2017
Iquito	Zaparoan	Peru	Michael 2010
Japanese	Japonic	Japan	Tsuchida 1997, 2001; Kilbourn-Ceron & Sonderegger 2018
Korean	Koreanic	Korea	Jun & Beckman 1993
Lezgian	Nakh-Daghestanian	North Caucasus	Chitoran & Babaliyeva 2007; Chitoran & Iskarous 2008
Malagasy	Malayo-Polynesian	Madagascar	O'Neill 2015
Mangghuer	Mongolic	China	Slater 2003
Miami-Illinois	Algonquian	N. America	Costa 2003
Mokilese	Malayo-Polynesian	Micronesia	Harrison & Albert 1976
Montreal French	Romance	N. America	Bayles 2016
Niuafo'ou	Malayo-Polynesian	Tonga	Tsukamoto 1988
Northeast Cree	Algonquian	N. America	Dyck, Power, & Terry 2014; Knee 2012, 2014
Northern Paiute	Uto-Aztecan	N. America	Thornes 2003; Louie 2010
Nyangumarta	Pama-Nyungan	Australia	O'Grady 1964; Sharp 2004
Oneida	Northern Iroquian	N. America	Michelson 1988; Gick et al. 2012
Orma (variety of Oromo)	Cushitic	Kenya	Hoskins 2011
Pisaflores Tepahua	Totonacan	Mexico	MacKay & Trechsel 2013
Rapa Nui	Malayo-Polynesian	Polynesia	Kievit 2017

Salar	Turkic	China	Dwyer 2007
Sandawe	Khoisan or isolate (apparently a bit disputed)	Tanzania	Hunziker, Hunziker, & Eaton 2008
Santa	Mongolic	China	Kim 2003
Shipibo	Panoan	Peru, Brazil	Ulloa 2006
Southern Paiute	Uto-Aztecan	N. America	Sapir 1930; Harms 1966
Southern Ute	Uto-Aztecan	N. America	Oberly & Kharlamov 2015
Tohono O'odham	Uto-Aztecan	N. America (US and Mexico)	Saxton 1963; Hill & Zepeda 1992; Fitzgerald 1997
Tongan	Malayo-Polynesian	Tonga	Feldman 1978
Tümpisa Shoshone	Uto-Aztecan	N. America	Dayley 1989
Turkana	Nilo-Saharan	Kenya	Dimmendaal 1983
Turkish	Turkic	Turkey	Jannedy 1995
Uyghur	Turkic	China	Hahn n.d.; Fiddler 2019
Wallaga Oromo	Cushitic	Ethiopia	Dissassa 1980
Woleaian	Malayo-Polynesian	Micronesia	Sohn 1975; Kennedy 2002
Zihuateutla Totonac	Totonacan	Mexico	Garcia-Vega 2022

Table A.1: Vowel Devoicing Database: languages, families, regions, sources

Language	**# of processes**	**Stress**	**Tone**	**Notes**
Acoma	3	yes	yes (interacts w/stress)	
Ainu	1	yes	no	
Andean Spanish	2	yes	no	
Ashéninka	1	yes	no	
Big Smoky Valley Shoshone	2			phonological info is limited, so details on VD and word prosody are missing
Blackfoot	1	yes	no	
Borana Oromo	1	no	yes	
Brazilian Portuguese	1	yes	no	

Cayuga	1	yes (primary and non-stress foot heads on alternating syllables)		
Chama	1	yes	no	
Cheyenne	3	no (but evidence for non-stress prosodic head in penultimate syllable)	yes	
Chickasaw	1	yes		
Cochabambino Spanish	1	yes	no	
Comanche	2	yes	sources differ on presence of tone, may have tone/stress interaction	
Ecuadorian Spanish	2	yes	no	
European French	2	no	no	
Fox	2	yes	no	
Gangou	1	no	yes	
Greek	1	yes	no	
Hrusso Aka	1	yes	no	
Ik	1	no	yes	
Iquito	1	yes	yes (interacts with stress)	
Japanese	2	no	yes (limited distribution, referred to as pitch accent)	varies by dialect and author. I focus on (Tsuchida 1997) and (Kilbourn-Ceron & Sonderegger 2018), since they disentangle several distinct processes
Korean	1	no	no	

Lezgian	1	yes	no	
Malagasy	1	yes	no	seems to vary by dialect, but not enough info in existing work to distinguish at this point
Mangghuer	1	yes	no	
Miami-Illinois	1	yes (word-level "accent" and segmental evidence for alternating weak/strong syllables)	no	
Mokilese	1	strong and weak syllable distinction based on weight (not described as stress)	no	
Montreal French	1	no (but arguments made for feet/metrical structure)	no	
Niuafo'ou	3	yes	no	
Northeast Cree	1	yes (primary stress and evidence for additional foot structure from segmental phonology)	no	
Northern Paiute	2	yes	no	
Nyangumarta	1	yes	no	
Oneida	1	yes	no	
Orma (variety of Oromo)	1	no	yes	
Pisaflores Tepahua	1	yes	no	
Rapa Nui	1	yes	no	
Salar	1	yes	no	

Sandawe	1	no	yes	
Santa	1	yes	no	
Shipibo	1	yes	yes but not independent from stress (stressed syllables said to bear high tone)	
Southern Paiute	2	yes	no	
Southern Ute	1	yes	no	additional pattern of word-final devoicing excluded from Database, which authors say is not phonologically predictable, but instead conditioned by morphological factors
Tohono O'odham	2	yes	no	
Tongan	2	yes	no	
Tümpisa Shoshone	2	yes	no	
Turkana	1	no	yes	
Turkish	1	yes	no	
Uyghur	1	yes	no	
Wallaga Oromo	1	yes	no	
Woleaian	1	no	no	
Zihuateutla Totonac	1	yes	no	

Table A.2: Vowel Devoicing Database: languages and their phonology

APPENDIX B

VOWEL DEVOICING DATABASE: ALL VOWEL DEVOICING PROCESSES

This table provides the full inventory of vowel devoicing processes in the VD Database, with the following information for each process: i) the language in which the process occurs, ii) whether the process is segmentally restricted (i.e. applies only in vowels adjacent to a certain set of voiceless and/or aspirated consonants), iii) whether it is prosodically restricted (i.e. applies only in one particular structural prosodic position), iv) what types of structural prosodic properties and/or tones block the process, v) whether the process is described as optional (yes = optional, no = obligatory, blank = unknown), and vi) which vowel qualities can devoice. (If vowel length is relevant, with only short vowels devoicing, that is noted here in the last category of information as well.)

Language	**Segmentally restricted?**	**Prosodically restricted?**	**Blocked by**	**Optional?**	**Vowel qualities**
Acoma	no	yes	stress, some tones	yes	all
Acoma	yes	no	stress, some tones	no	all
Acoma	yes	yes		yes	all
Ainu	yes	no	rare in stressed syllable	yes	high
Andean Spanish	yes	no	stress	yes	high and /e/
Andean Spanish	yes	yes	stress	yes	all
Ashéninka	yes	no	stress	yes	/i/
Big Smoky Valley Shoshone	no	yes		yes	all short
Big Smoky Valley Shoshone	yes	no	left edge of word	no	all short
Blackfoot	no	yes		no	all short
Borana Oromo	no	yes	high tone, phrase-final position	no	all short
Brazilian Portuguese	yes	yes	stress	no	all
Cayuga	yes	no	stress, non-stress foot-heads	no	all
Chama	no	yes	stress		all

Cheyenne	no	yes		no	all
Cheyenne	yes	yes		no	all
Cheyenne	yes	no	non-stress word level prominence, high tone	no	all
Chickasaw	yes	yes		yes	all
Cochabambino Spanish	yes	no	stress	yes	all
Comanche	no	yes		yes	all short
Comanche	yes	no	stress	no	all short
Ecuadorian Spanish	yes	yes	stress	yes	mostly /i, e/
Ecuadorian Spanish	yes	yes		yes	mostly /i, e/
European French	no	yes		yes	high and mid
European French	yes	no		yes	high
Fox	no	yes			all
Fox	yes	no	stress		all
Gangou	yes	no		yes	/i, u/
Greek	yes	no	stress	yes	high
Hrusso Aka	yes	no	stress		high
Ik	no	yes			
Iquito	no	yes		no	all short
Japanese	yes	no	high tone (in some varieties, causes high tone to shift)	no	high
Japanese	yes	yes		yes	high
Korean	yes	no		yes	high
Lezgian	yes	yes		no	high
Malagasy	no	yes	stress	yes	all
Mangghuer	yes	no	rare in stressed syllable	yes	/i, e, u/
Miami-Illinois	yes	no	“strong” syllables		all
Mokilese	yes	no	“strong” syllables	yes	high
Montreal French	yes	no	phrasal stress	yes	high

Niuafo'ou	yes	no	stress, word-initial syllable	no	all
Niuafo'ou	yes	no	stress, word-initial syllable	no	high
Niuafo'ou	yes	no	stress, word-initial syllable	no	high
Northeast Cree	yes	no	stress, non-stress foot-heads	yes	high
Northern Paiute	yes	no	stress	yes	all short
Northern Paiute	yes	yes	stress	yes	all short
Nyangumarta	no	yes		yes	all
Oneida	no	yes	stress	no	all short
Orma (variety of Oromo)	no	yes	high tone	no	all short
Pisaflores Tepehua	no	yes	stress	no	all
Rapa Nui	yes	yes	stress/long vowels (final vowels are only stressed if they are long, and these vowels never devoice)	yes	all short
Salar	yes	no	stress	no	high
Santa	yes	yes?		yes	/i, u, e/
Shipibo	yes	no	stress	yes	all short
Southern Paiute	no	yes		no	all
Southern Paiute	yes	no	stress	no	all
Southern Ute	yes	no	stress		all
Tohono O'odham	no	yes	stress		unclear
Tohono O'odham	yes	no	stress		/i, ɨ/

Tongan	yes	no	stress	no	high short
Tongan	yes	no	stress	no	all
Tümpisa Shoshone	no	yes		yes	all short
Tümpisa Shoshone	yes	no		yes	all short
Turkana	no	yes		no	all
Turkish	yes	no	stress	yes	high
Uyghur	yes	no	stress	yes	high
Wallaga Oromo	no	yes	stress	no	all short
Woleaian	no	yes			high and mid
Zihuateutla Totonac	yes	yes	stress		all

Table B.1: Vowel Devoicing Database: all processes

APPENDIX C

VOWEL DEVOICING DATABASE: PURELY SEGMENTALLY RESTRICTED VOWEL DEVOICING PROCESSES

This table presents more detailed information for all of the purely segmentally restricted vowel devoicing processes (i.e. those that apply only adjacent to certain sets of voiceless and/or aspirated consonants). It lists the language in which each process is found, the position of the consonantal trigger relative to the vowel, the type of consonantal trigger, and any additional notes on the process.

Language	**Position of C trigger**	**Type of C trigger**	**Notes**
Acoma	left of vowel	voiceless fricatives	
Ainu	both sides of vowel	voiceless consonants	
Andean Spanish	either side of vowel (especially common when on right side of vowel)	voiceless consonants	
Ashéninka	left of vowel	unclear	sources differ in descriptions of consonantal trigger
Big Smoky Valley Shoshone	right of vowel	/h/	
Cayuga	right of vowel (must be coda)	/h/	when /h/ is intervocalic, it metathesizes with preceding vowel instead
Cheyenne	right of vowel	voiceless fricatives	
Cochabambino Spanish	either side of vowel	voiceless consonants	
Comanche	right of vowel	voiceless fricatives	
European French	either side of vowel	voiceless consonants (especially common with voiceless fricatives)	
Fox	right of vowel	voiceless fricatives	
Gangou	left of vowel	aspirated stops, aspirated affricates, fricatives	no voicing or aspiration contrast in fricatives (seems they are all voiceless unaspirated)
Greek	either side of vowel	voiceless consonants	

Hrusso Aka	left of vowel	voiceless consonants	
Japanese	both sides of vowel	voiceless consonants	
Korean	both sides of vowel	voiceless consonants	
Mangghuer	left of vowel	voiceless consonants	devoicing most common after /h/, followed by other voiceless fricatives (less common after other types of voiceless consonants)
Miami-Illinois	right of vowel	preaspirated consonants	
Mokilese	both sides of vowel	voiceless consonants	
Montreal French	either side of vowel	voiceless consonants	
Niuafo'ou	left of vowel	/h/	
Niuafo'ou	both sides of vowel; or left side if vowel is word-final	voiceless consonants	
Niuafo'ou	left of vowel	voiceless fricatives	
Northeast Cree	either side of vowel	voiceless consonants	
Northern Paiute	left of vowel	voiceless fricative or affricate	
Salar	both sides of vowel	voiceless consonants	
Shipibo	both sides of vowel	between voiceless fricative and voiceless stop	
Southern Paiute	right of vowel	geminate voiceless consonants	
Southern Ute	right of vowel	voiceless consonants	
Tohono O'odham	unclear	unclear	the precise segmental restrictions are a bit unclear and and vary from source to source

Tongan	both sides of vowel; or left side if vowel is utterance-final	/h/ to left of vowel; voiceless consonants or utterance boundary to right of vowel	different sets of triggering Cs for different vowel qualities; source notes interactions with morphology, but phonological environment seems to be sufficient predictor in the available examples
Tongan	both sides of vowel; or left side if vowel is utterance-final;	voiceless consonants	different sets of triggering Cs for different vowel qualities
Tümpisa Shoshone	both sides of vowel	voiceless consonants	
Turkish	either side of vowel	voiceless consonants	
Uyghur	both sides of vowel	voiceless consonants	

Table C.1: Vowel Devoicing Database: purely segmentally restricted

APPENDIX D

VOWEL DEVOICING DATABASE: PURELY PROSODICALLY RESTRICTED VOWEL DEVOICING PROCESSES

This table presents more detailed information for all of the purely prosodically restricted vowel devoicing processes (i.e. those that apply only in one specific structural prosodic position). It lists the language in which each process is found, the type of prosodic position to which the process is restricted, the size of the prosodic domain at which the process applies (only for processes with domain-final restrictions), and any additional notes on the process. As noted in Chapter 3 of this dissertation, it is not possible to consistently distinguish among multiple phrase and/or utterance sized prosodic constituents using the existing materials on each language included in the Database. I therefore only distinguish between two sizes of domains: word and large domain, with the latter including any constituent larger than the word.

Language	**Type of prosodic restriction**	**Size of domain**	**Notes**
Acoma	domain-final	word	
Big Smoky Valley Shoshone	domain-final	unclear	
Blackfoot	domain-final	large domain	
Borana Oromo	domain-final	word	
Chama	domain-final	large domain	
Cheyenne	domain-final	large domain	
Comanche	domain-final	large domain	
European French	domain-final	large domain	
Fox	domain-final	large domain (see note)	described as word-final but based on data in source, appears to be large domain-final
Ik	domain-final	large domain	
Iquito	domain-final	large domain	
Malagasy	domain-final	large domain	
Nyangumarta	domain-final	large domain	
Oneida	domain-final	large domain	
Orma (variety of Oromo)	domain-final	word	
Pisaflores Tepahua	domain-final	large domain	
Southern Paiute	domain-final	word	

Tohono O'odham	domain-final	word	there may be a distinct phrase-final process, but there is not enough information from available materials to verify this
Tümpisa Shoshone	domain-final	large domain	
Turkana	domain-final	large domain	
Wallga Oromo	domain-final	word	
Woleaian	domain-final	word	

Table D.1: Vowel Devoicing Database: purely prosodically restricted

APPENDIX E
VOWEL DEVOICING DATABASE: PROSODICALLY AND SEGMENTALLY RESTRICTED VOWEL DEVOICING PROCESSES

This table presents the prosodically and segmentally restricted vowel devoicing processes (i.e. those that apply only in one specific structural prosodic position, in vowels adjacent to a certain set of voiceless and/or aspirated consonants). It lists the language in which each process is found, the type of consonantal trigger and their position relative to the vowel, the type of prosodic position to which the process is restricted and the size of the prosodic domain (for processes with domain-final restrictions), and any additional notes on the process.

Language	**Type of C trigger**	**Position of C trigger**	**Type of prosodic restriction**	**Size of domain**	**Notes**
Acoma	voiceless consonants	both sides of vowel	pre-accentual		
Andean Spanish	voiceless consonants	either side	domain-final	word	
Brazilian Portuguese	voiceless consonants	left of vowel	domain-final	word	
Cheyenne	voiceless consonants	right of vowel	domain-final	word	vowel epenthesis after word-final obstruents obscures underlying word-final environment
Chickasaw	voiceless consonants	right of vowel	unstressed word-initial		
Ecuadorian Spanish	voiceless fricative (particularly /s/)	right of vowel	domain-final	word	
Ecuadorian Spanish	voiceless fricative (particularly /s/)	either side	immediately pretonic		
Japanese	voiceless consonants	left of vowel	domain-final	word	

Lezgian	voiceless consonants	left of vowel	immediately pretonic		description says process is triggered by voiceless consonant to left of vowel, but all examples show two voiceless consonants on both sides of vowel
Northern Paiute	voiceless consonants	left of vowel	domain-final	word	unlike vowel devoicing processes, this optionally spreads leftward to multiple syllables (depending on additional segmental factors and stress)
Rapa Nui	voiceless consonants	left of vowel	domain-final	word	
Santa	voiceless consonants to left and aspirated stops or voiceless fricatives to right vowel	both sides of vowel	unstressed word-initial		status of prosodic restriction unclear from source (specifically whether there are unstressed non-initial syllables that exhibit the relevant segmental environment but not VD)

Zihuateutla Totonac	voiceless consonants (specifically voiceless obstruents)	left of vowel	domain-final	large domain	

Table E.1: Vowel Devoicing Database: prosodically and segmentally restricted

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