**Title**

# Deriving Natural Classes: The Phonology and Typology of Post-velar Consonants



**Author**
Sylak-Glassman, John

**Publication Date**
2014

**Deriving Natural Classes: The Phonology and Typology of Post-Velar Consonants**

by

John Christopher Sylak-Glassman

A dissertation submitted in partial satisfaction of the
requirements for the degree of
Doctor of Philosophy

in

Linguistics

in the

Graduate Division

of the

University of California, Berkeley

Committee in charge:

Professor Sharon Inkelas, Chair
Professor Andrew Garrett
Professor Keith Johnson
Professor Darya Kavitskaya

Spring 2014

**Deriving Natural Classes: The Phonology and Typology of Post-Velar Consonants**

# Abstract

Deriving Natural Classes: The Phonology and Typology of Post-Velar Consonants

by

John Christopher Sylak-Glassman

Doctor of Philosophy in Linguistics

University of California, Berkeley

Professor Sharon Inkelas, Chair

In this dissertation, I propose a new method of deriving natural classes that is motivated by the phonological patterning of post-velar consonants (uvulars, pharyngeals, epiglottals, and glottals). These data come from a survey of the phonemic inventories, phonological processes, and distributional constraints in 291 languages.

The post-velar consonants have been claimed to constitute an innate natural class, the gutturals (McCarthy 1994). However, no single phonetic property has been shown to characterize every post-velar consonant. Using data from *P-base* (Mielke 2008), I show that the phonological patterning of the post-velar consonants is conditioned by the presence of a pharyngeal consonant, and argue more generally that natural classes can be derived from phonetic connections that link specific subsets of phonemes. Phonological entailments (Burzio 2002a,b; Wayment 2009) are used to model these connections. Entailments are derived from the co-occurrence of features within a single phoneme, and state that if one element of representation ($p$) is present, then so is another ($q$). Entailments are central to deriving natural classes, and function as a source of explanation for why phonemes are able to pattern together.

Because natural classes are proposed to be derived rather than representationally specified, I propose that formal representations are responsible for capturing phonemic contrast and phonetic detail that is essential for accurately describing phonological processes and distributional constraints. Following this proposal, I present a new formal representation of the post-velar consonants. Traditional phonological features are associated with the phoneme itself and are motivated by the phonemic contrasts discovered through the typological survey. In addition, phonetic subfeatures are associated with language-specific allophones of phonemes and are motivated by phonological processes that are influenced by non-contrastive phonetic properties.

Natural classes are derived as feature classes (symbolized $\mathbb{C}$; Padgett 1995, 2002), which are sets of feature bundles combined in a union relationship. Their composition is derived using a new type of Optimality Theory constraint, ASSOCIATE($\mathbb{C}_i$, $p \leftrightarrow q$), which uses entailments to require the feature bundles represented by $p$ and $q$ to be present in a feature class, $\mathbb{C}_i$. I argue that the entailments in these constraints establish a surface correspondence relationship between the feature bundles that they require to be present, and that regulating this correspondence relationship

is key to determining the composition of feature classes within a language. MAX-FF$_{\mathcal{C}}$ requires feature bundles to be in correspondence, which eliminates feature bundles that are not required by ASSOCIATE constraints. DEP-FF$_{\mathcal{C}}$ militates against feature bundles being in correspondence, and its ranking with respect to the ASSOCIATE constraints determines which feature bundles are included in a feature class. The feature bundles required by ASSOCIATE constraints ranked above DEP-FF$_{\mathcal{C}}$ are included in a feature class, while those that are required by ASSOCIATE constraints ranked below DEP-FF$_{\mathcal{C}}$ are not. The dissertation concludes by demonstrating that this proposed system can derive natural classes composed of post-velar consonants, including the guttural natural class in Arabic.

To my aunt, Dr. Mary Diane Lazar

# Contents

# List of Figures

# List of Tables

## Acknowledgments

First and foremost, I'd like to thank my advisor, Sharon Inkelas, who guided me through graduate school and constantly supported me and my research both intellectually and professionally. Our meetings always opened my eyes to new possibilities for gathering data and sharpening my analysis. Her eagerness to listen to my ideas and help me develop them further enriched all of my work. Her seminar on similarity in phonology and interest in Agreement by Correspondence provided crucial intellectual contributions to the theoretical analysis in this thesis. Without Sharon's constant support and guidance, this dissertation would not have been possible.

I'd also like to thank the members of my committee, Andrew Garrett, Keith Johnson, and Dasha Kavitskaya, for their help, advice, and thoughtful comments throughout writing this thesis and graduate school as a whole. Thank you to Andrew for helping me to cultivate my interest in languages of the Americas by giving me the opportunity to work at the Survey of California and Other Indian Languages, inviting me to participate in a Wakashan reading group, and advising me in my research on Ditidaht. Moreover, Andrew's guidance in all matters historical has been helpful not only in this thesis, but in my other research as well. Thank you to Keith for advising me in detail on statistics and experimental methods, for his perspective on natural classes and featural representation, and generally for his cheerfulness and optimism. Thank you also to Dasha for her advice throughout writing this thesis and for agreeing to delve into the literature on Soviet language policy and linguistic geography in the Caucasus to hold a small seminar with me as part of my FLAS Fellowship.

Thanks are also due to Johanna Nichols for giving me the opportunity to study pharyngealization in Chechen. Prior to coming to graduate school, Victor Friedman inspired me to study the languages of the Northeast Caucasus (Lak in particular) and to come to Berkeley, and I thank him heartily for that. I am also grateful to Jason Riggle for fostering my interest in theoretical phonology and for encouraging me to go to the west coast for graduate school.

Thank you also to Justin Lei, who gathered phonemic inventories for the Athabaskan, Formosan, and Iranian languages. Without his help as part of the Department of Linguistic's LRAP program, my typological survey would be considerably less complete.

Thank you also to Lev Michael for training me to do fieldwork in field methods and in the Peruvian Amazon. I am also grateful for his efforts in putting together SAPhon, which was extremely helpful in surveying the languages of South America.

I also owe a great debt of thanks to everyone who helped me in my work with the Ditidaht language. Even though my work on post-velar consonants in Ditidaht could not be included in this thesis, I'd like to thank all those who contributed to it. First, I must thank the committee of professors at Berkeley who supported my project and awarded me the Oswalt Endangered Language Grant twice to support my work. I also gratefully acknowledge the financial support of the UC Berkeley Graduate Division's Summer Grant and Travel Grant. Many people, including Pat Shaw, Adam Werle, Randy Bouchard, and Deborah Mack, helped me to establish contacts and begin to work with speakers of Ditidaht. I am especially grateful to Deborah Mack and to all the members of the Ditidaht First Nation who supported and encouraged me in my work. Finally, I am grateful most of all to the speakers who agreed to spend time working with me and helping me understand the Ditidaht language, including Dorothy Shepherd, Michael Thompson, Christine Edgar, and Jimmy Chester Jr.

Thank you also to the members of the University of Victoria linguistics department, who gave me an academic home-away-from-home on Vancouver Island. I'm especially grateful to John Esling for letting me spend a day in the department and learn about laryngoscopy firsthand. Thank you also to Ewa Czaykowska-Higgins and Sonya Bird for their insightful input on my work and their enthusiasm for it.

I would also like to specially thank Scott Moisik, whose own work was fundamental to my understanding of the phonetics and phonology of post-velar consonants, particularly pharyngeals. Thank you also to Florian Lionnet for his advice on the languages of the Kalahari Basin and for discussing theoretical phonology with me.

I also thank the organizations that have supported me financially through the Beinecke Brothers Scholarship and the Foreign Language and Area Studies Fellowship. I am also grateful for all the support that the Department of Linguistics has provided over the years.

I have been lucky to have not only a great deal of academic support, but a strong network of family and friends who have never wavered in encouraging me. The community of graduate students at UC Berkeley has always been a source of fun and inspiration, and I'm particularly grateful to my friends and cohort-mates Melinda Fricke, Stephanie Farmer, Clara Cohen, and Jessica Cleary-Kemp, who first made me feel like California could be home. Thank you also to Florian Lionnet, Daisy Rosenblum, Stephanie Shih, Nico Baier, Zach O'Hagan, and Nik Rolle for helping me get through the day-to-day of writing my thesis with coffee breaks and great conversations. I would also like to thank Matthew Chapman, Doran Bennett, Nina Bennett, and many others for their deep and meaningful friendships. There are doubtless other friends who I am forgetting here, and who deserve my thanks.

I'd also like to thank my mom, dad, and sisters for supporting me throughout my whole life and giving me all the opportunities that they did. I can't thank them all enough.

Finally, thank you to my wife, Emily Sylak-Glassman. Thank you for being there for all the celebrating, the commiserating, and the thinking-through that went into this dissertation. Thank you for being my partner through everything (especially fieldwork) and for always being my rock. Words could never convey how thankful I am to have you in my life and how much your love means to me.

# Chapter 1

# Introduction

## 1.1 The Problem: Deriving Phonological Classes and Defining Naturalness

A core phenomenon to be explained by phonological theory is that certain groups of phonemes pattern together in multiple languages. For example, in Spanish, the voiced stops /b, d, g/ are realized as the fricatives [β, ð, ɣ] when they occur "non-initially, except after a homorganic nasal or lateral" (Kirchner 1998:7, citing Harris 1969).

(1) /b, d, g/ ⟶ [β, ð, ɣ] "non-initially, except after a homorganic nasal or lateral"

| | | | |
|---|---|---|---|
| *ribera* | /ribera/ | [riβera] | 'riverbank' |
| *dedo* | /dedo/ | [deðo] | 'finger, toe, digit' |
| *contigo* | /kontigo/ | [kontiɣo] | 'with you (sg.)' |

The fact that /b, d, g/ are affected (or behave) in the same way in Spanish indicates that in that language, they are a *phonological class*.

A similar process involving approximately the same phonemes and changes to them, but in a different conditioning environment, occurs in Lowland Murut (Timugon, Austronesian; Gurevich 2013 citing Halle and Clements 1983; Prentice 1971).

(2) /b, d, g/ ⟶ [β, ɾ, ɣ] / V__ (data from Halle and Clements 1983:57)

| | | |
|---|---|---|
| /abag/ | [aβaɣ] | 'loincloth' |
| /sɔdɔj/ | [sɔɾɔj] | 'remain' |
| /gigiul/ | [giɣiul] | 'wooden spatula' |

The fact that this same phonological class, /b, d, g/, is found in another unrelated language indicates that the basis for the phonological class is some characteristic that is intrinsic to language itself and not the idiosyncratic property of an individual language. This leads phonologists to call this class a *natural class*.

Phonological classes are defined only by the fact that their member phonemes behave the same way in a derivation, and they can be either natural or unnatural (Mielke 2008:13). A *natural class* often occurs in multiple unrelated languages, indicating that some principle common to human language as a whole may explain the grouping of the phonemes in the class. Often, a natural class is a phonological class of phonemes whose grouping can be explained in terms of phonetic factors that exclude all other phonemes (12). In contrast, an *unnatural class* is a phonological class whose grouping cannot be explained this way and which is expected to be language specific. For example, in Evenki (Tungusic), the phonemes /v, s, g/ nasalize to become /m, n, ŋ/, respectively, after a nasal consonant (Mielke 2008:120 citing Nedjalkov 1997:175, 320).

(3) /v, s, g/ ⟶ /m, n, ŋ/ (Nedjalkov 1997)[1]

| | | |
|---|---|---|
| /oron-vi/ | [oronmi] | 'my reindeer (sg.)' (149) |
| /ŋinakin-si/ | [ŋinakinni] | 'your dog' (320) |
| /oron-gAt͡ʃin/ | [oronŋot͡ʃin] | 'like a/the reindeer' (149) |

A fundamental goal of phonological theory is to formally distinguish between natural and unnatural classes. Chomsky and Halle (1968:335) wrote that "if a theory of language failed to provide a mechanism for making distinctions between more or less natural classes of segments, this failure would be sufficient reason for rejecting the theory as being incapable of attaining the level of explanatory adequacy." Achieving this involves providing both a formal derivational mechanism for making that distinction and a definition of "naturalness."

Previous approaches to defining and explaining natural classes have suffered from a lack of empirical coverage or from not adequately distinguishing natural from unnatural classes. In representational approaches, such as shared feature specification (Chomsky and Halle 1968) and Feature Geometry (Sagey 1990), the natural classes are proposed to be specified directly by combinations of phonological features and are posited as innate structures of the human ability to acquire and use language. While these theories make clear and strong predictions, they are not able to capture phonological classes that are natural because of the phonetic facts that explain their patterning, but which are not able to be represented by a combination of features or under a single feature geometric node.

In contrast, derivational approaches (such as that of Flemming 2005 and Mielke 2008) are very flexible and are able to derive all phonological classes in a language. For example, in the approach adopted in Flemming (2005), "natural classes" are formally equivalent to phonological classes because they are defined as any group of phonemes that is affected the same way in a derivation. Because of this, there is no formal distinction between natural and unnatural classes in the sense that natural classes have a phonetic basis and may occur in multiple languages. This means that these derivational frameworks are not able to make predictions about which phonological classes would be expected to occur across multiple languages.

In this dissertation, I propose a new theoretical framework that derives phonological classes and distinguishes natural classes from unnatural classes by grounding the derivation of natural classes in phonetic connections between phonemes. Although previous derivational approaches were able to derive all phonological classes and previous representational approaches were able to distinguish between natural and unnatural classes, no previous framework has been able to do both.

[1] Mielke (2008:120) notes that "/A/ is an archiphoneme whose phonetic realization is determined by the preceding harmonic vowel." For more details on vowel harmony in Evenki, see Nedjalkov (1997:314-315).

The theoretical framework that I propose here is motivated by data on phonological classes composed of post-velar consonants that indicates that phonetic connections between specific phonemes may be the basis of their patterning together. The approach here is founded on the insight that these lower-level connections between phonemes may combine to form larger natural classes. I claim that this is the explanation for why the guttural natural class was posited, but had no single unifying phonetic characteristic: The class is natural, but it is natural by virtue of multiple phonetic connections that unify the phonemes, not one single characteristic.

## 1.2 Post-Velar Consonants and the Guttural Natural Class

Hayward and Hayward (1989) and McCarthy (1991, 1994), working in the Feature Geometry framework, proposed the existence of an innate natural class called the *guttural natural class* that includes the post-velar consonants. The post-velar consonants include the uvular, pharyngeal, epiglottal, and glottal consonants. Hayward and Hayward (1989) and McCarthy (1991, 1994) used phonological evidence from Semitic and Cushitic languages to argue for the existence of the class. While this evidence is sound, the existence of the guttural natural class faced two challenges.

The first challenge is that cross-linguistically, not all post-velars in a language always pattern as members of the guttural natural class. For example, Bessell (1992) showed that evidence for the guttural natural class in the Interior Salish languages demonstrated that glottals were not part of that class. Moreover, within Arabic itself, the uvular stop /q/ often acts differently than the core gutturals, /χ, ʁ, ħ, ʕ, ʔ, h/ (McCarthy 1994). Finally, a query of *P-base*, a database of phonological classes from over 500 languages (Mielke 2008), suggests that languages with pharyngeal consonants are more likely to show evidence for the guttural natural class than languages without pharyngeal consonants, but with both uvulars and glottals. These sources of variability suggest that the post-velar consonants are not all equally likely to pattern together, which in turn suggests that phonetic differences at the level of place of articulation and even at the level of the phoneme may influence the phonological patterning of post-velar consonants.

The second challenge is that in contrast to natural classes like the labials, coronals, and dorsals, the guttural natural class is not unified by a single active articulator and possibly not by any other single phonetic factor. Articulatory research by John Esling and colleagues revealed important articulatory connections between spatially contiguous groupings of the post-velar consonants, but no single connection between all post-velar consonants. Similarly, Zawaydeh (2003) proposed that the phonetic explanation for why post-velar consonants pattern together varies by language, with some languages, like Arabic, showing patterning based on acoustic similarity, namely high F1, with other languages, like the Interior Salish languages, showing patterning based on articulatory similarity, namely narrower pharyngeal width. Finally, although Bin-Muqbil (2006:244-247) proposed that the post-velar consonants act together based on their active articulators being innervated by the X vagus cranial nerve, this proposal has not been widely adopted.

Because of these challenges, the formal representation of the post-velar consonants and the explanation for why they pattern together in phonological classes are still not fully determined. Nevertheless, the evidence for phonological classes composed primarily of post-velars is strong, and the phonetic connections between certain subsets of the post-velar consonants are clear. Phonological classes composed of post-velar consonants are therefore ideal objects of analysis for the new approach to deriving natural classes that I propose here. This new approach is able to formalize the idea that multiple phonetic connections unify the phonemes in what has been called the guttural natural class. Moreover, because the phonetic connections that build natural classes unify small subsets of phonemes directly, cross-linguistic variation is not a problem. As long as the varying phonological classes all have phonetic explanations that underlie their composition, then these explanations need only be incorporated into the analysis.

## 1.3 Deriving Natural Classes Based on Phonetic Connections Between Phonemes

As a result of proposing that natural classes should be derived, rather than specified via representation, this dissertation also advocates a new understanding of the role of phonological representations. In most frameworks, phonological representations have been responsible for explaining both phonemic contrast and phonological class behavior. I propose here that phonological representation should be responsible only for explaining phonemic contrast and for capturing non-contrastive phonetic details that are relevant to describing phonological processes and distributional constraints (i.e. sound patterns). Phonological features, which are motivated by phonemic contrast, are considered to be associated with phonemes and definitional of them, regardless of which language the phoneme occurs in. These phonological features are supplemented by phonetic subfeatures, which are formally associated with a phoneme's allophones in a specific language and which are used to capture phonetic details that are not contrastive but are still phonologically relevant.

The theoretical system for deriving natural classes is based on phonological entailments, which are formal statements of the form $p \rightarrow q$ that are derived from the co-occurrence of phonological features or phonetic subfeatures within a single phoneme attested in some language (Burzio 2002a,b; Wayment 2009). These entailments are incorporated into a new type of Optimality Theory constraint with the form ASSOCIATE($\mathcal{C}_i$, $p \leftrightarrow q$). These constraints use two entailments, $p \rightarrow q$ and $q \rightarrow p$, to require the feature bundles $p$ and $q$ to be included in a natural class. Natural classes, in turn, are formally feature classes. Feature classes, first proposed by Padgett (1995, 2002), are sets of feature bundles that are combined as a set-theoretic union, and they are symbolized as $\mathcal{C}$, with a possible subscript label ($\mathcal{C}_i$). The feature bundles of a feature class represent the phonemes they stand for. For example, if there were a feature class $\mathcal{C}$ = $\{$[+voiced, -continuant] $\cup$ [+nasal]$\}$, that feature class would represent the set of phonemes $\{$/b, d, g, m, n/$\}$. In this system, natural classes are derived, rather than specified, and naturalness is grounded in phonological entailments.

The ASSOCIATE constraints establish a surface correspondence relationship between the feature bundles that they require to be present in a feature class, and regulating this correspondence relationship is the key to determining which feature bundles are in a feature class. The constraint MAX-FF$_{\mathcal{C}}$ penalizes feature bundles that are not in a correspondence relationship, and thus eliminates formally extraneous features that are not called for by any ASSOCIATE constraints. DEP-FF$_{\mathcal{C}}$

penalizes feature bundles for being in a correspondence relationship, and is thus able to countervail the influence of ASSOCIATE constraints. The feature bundles required by the ASSOCIATE constraints ranked above DEP-FF$_C$ are included in a feature class, while those that are required by ASSOCIATE constraints that are ranked below DEP-FF$_C$ are excluded. This system is explained in detail in chapter 5 and demonstrated using phonological classes of post-velar consonants in chapter 6.

The advantages of this new system are, first, that it derives natural classes instead of specifying them, which allows it to formally account for a wider range of phonological classes that are natural because of the phonetic explanations that underlie them. Second, the system is based on an explicit derivational notion of naturalness. Naturalness is directly reflected in the co-occurrence of phonological features or phonetic subfeatures, which gives rise to entailments. Entailments can be used to explain the naturalness of phonological classes through the derivational system proposed in this dissertation. This new system therefore accounts for a wider range of data using a more robust method of incorporating phonetics than previous approaches. Third, the use of entailments also allows the new system to make more nuanced predictions than representational approaches. In the new system, possible natural classes include any phonological class in which the phonemes are linked together by demonstrable phonetic connections that can be formulated as entailments. In contrast, previous representational approaches can only explain natural classes using a small set of pre-selected phonetic facts.

## 1.4 Overview

This dissertation presents the new theoretical framework for deriving natural classes described above through a systematic examination of the post-velar consonants and their cross-linguistic phonological behavior.

Chapter 2 surveys over 300 languages from areas of the world in which many of the languages contain (non-glottal) post-velar consonants.[2] This is the most extensive survey yet of languages with at least one non-glottal post-velar consonant and it encompasses the majority of such languages. The survey shows which post-velar consonants are attested in the languages of the world, and highlights areal patterns in their distribution that suggest a possible correlation with residual zones (Nichols 1992). By presenting the phonemic oppositions between post-velar consonants in most of the languages in which they are attested, it provides the empirical foundation for chapter 4 on the phonological representation of post-velar consonants.

Chapter 3 surveys the sound patterns (i.e. phonological processes and distributional constraints) in which post-velar consonants play a special role, and sets out the phonological class behavior that must be accounted for by the proposed system of deriving natural classes. Two major types of phonological processes in which post-velar consonants play a special role are local effects on vowels and processes of post-velar harmony. Post-velar consonants frequently cause lowering on adjacent vowels. They cause backing less frequently than might be expected, and pharyngeals

[2]Because languages with no post-velar consonants other than glottals (such as English) are extremely common, the focus is on languages which have non-glottal post-velar consonants.

actually cause fronting in a number of languages. In post-velar harmony systems, uvularization or pharyngealization (which are never contrastive within a single language) spread in a variety of processes. These include CV harmony processes (as in Arabic emphasis spread), processes in which spreading happens at the level of prosodic units like the word or syllable (as in Azerbaijani Jewish Aramaic or Berber languages), and separate consonant harmony and vowel harmony processes (as in Rutul and Tsilhqot'in). Post-velar harmony processes are attested in languages of the Middle East and North Africa, the Pacific Northwest Coast of North America, and in the Northeast Caucasus. Finally, other processes in which post-velars play a special role, such as co-occurrence restrictions, are reviewed.

Chapter 4 focuses on motivating and describing a new approach to the formal representation of phonemes. It begins with a brief history of formal phonological representations, and then reviews previous approaches to representing the post-velar consonants. Reviewing the strengths and shortcomings of these previous approaches helps to motivate the new approach to formal phonological representation as a whole, in which representations are responsible only for capturing phonemic contrast and phonologically relevant phonetic detail, not for capturing phonological class behavior. Traditional phonological features associated with the phoneme itself capture phonemic contrast while phonetic subfeatures associated with allophones in a particular language are used to capture phonetic detail that is not contrastive, but is relevant to describing sound patterns. After presenting this approach to phonological representation, the chapter turns to a systematic review of the phonemic contrasts attested between post-velar consonants in chapter 2. These contrasts motivate a new phonological feature representation that incorporates insights from Esling (2005)'s Laryngeal Articulator Model to more accurately model tongue position and that models pharyngeal articulations using the feature [±constricted epilarynx], based on articulatory research on pharyngeals (Moisik and Esling 2011; Moisik 2013).

Chapter 5 centers around describing a new theoretical system for deriving natural classes. The chapter begins by reviewing previous conceptions of phonological classes, especially as they relate to post-velar consonants, and this serves as motivation for a new approach to capturing natural class generalizations. This approach derives unnatural classes as the byproducts of Optimality Theoretic constraint interaction, following Flemming (2005), and derives natural classes using a new theoretical framework. This framework is built on phonological entailments, which arise from the co-occurrence of phonological features and phonetic subfeatures within a single attested phoneme. The representations from chapter 4 are therefore crucial for defining the possible entailments that arise from post-velar consonants. These entailments are used to motivate the inclusion of phonemes in natural classes, which are formalized as feature classes (Padgett 1995, 2002). The chapter then concentrates on explaining how membership in these classes is regulated through the use of a new family of Optimality Theory constraints, the ASSOCIATE constraints. These are argued to establish surface correspondence relationships between the feature bundles they require, and regulating these relationships through the constraints MAX-FF$_{\complement}$ and DEP-FF$_{\complement}$ is crucial to determining which feature bundles are included in a feature class. The chapter concludes with predictions made by this approach.

After explaining the theoretical system for deriving natural classes in chapter 5, chapter 6 focuses on exemplifying the derivation of natural classes that involve post-velar consonants. The chapter begins by presenting the results of querying *P-base*, which show that the phonetic connections between post-velar consonants are likely the reason that they pattern together in phonological classes (as opposed to patterning together because of membership in an innate guttural natural class). After this discussion, examples of how to derive natural classes with post-velar consonants are shown. These concentrate on showing the derivation of phonological classes that are composed of consonants at various combinations of post-velar places of articulation. The examples include classes composed of pharyngeals and glottals in Tiberian Hebrew, uvulars and pharyngeals in Coeur d'Alene, and uvulars and glottals in Filomeno Mata Totonac. The final derivation is of Arabic's guttural natural class, which includes uvular fricatives, pharyngeals, and glottals. The chapter concludes with a discussion of the naturalness metrics that are made possible by the proposed derivational approach.

The dissertation concludes in chapter 7 with a brief summary and a discussion of future directions for research on natural classes and on post-velar consonants.

# Chapter 2

# Cross-Linguistic Distribution of Post-Velar Consonants

## 2.1 Introduction

To determine the best phonological representation for the post-velar consonants using phonemic contrast, it is necessary to understand which phonemic contrasts exist between post-velar consonants within each language. This chapter is devoted to a new survey of the languages in which post-velar consonants occur, and shows both which post-velar consonants exist and which phonemic contrasts exist between the post-velar consonants in each language. These are later used to motivate a new phonological representation of the post-velar consonants in §4.

The survey proceeds by identifying geographical clusters of languages with post-velar consonants (§2.2). The majority of documented languages in the world that contain post-velar consonants are represented in the survey, but some languages are not. To the extent that it is known which languages these are, they are discussed in §2.4.1. The results of the survey (§2.3) show which post-velar consonants are attested and how common each of these are among the languages in the survey. The geographic distribution of languages in the survey also highlights spatial patterns that point to possible correlations between the distribution of post-velar consonants, residual zones (Nichols 1992:13), and even human migration patterns into the Americas, though these correlations must remain speculative.

## 2.2 Geographic Clusters of Languages with Post-Velar Consonants

The geographic distribution of the post-velar consonants is not even, and languages with post-velar consonants tend to fall into geographic clusters. The survey is presented by highlighting relevant geographic areas where more than one stock of languages is present in which at least some of the languages contain one or more post-velar consonants. It is important to mention that these geographic areas are not claimed here to be Sprachbünde (linguistic areas). The stocks in each area are presented, along with the languages that comprise those stocks. Languages that do not contain post-velars but that are in the area are also presented to show the diversity within the stock and area.

For each language, the velar (VEL), uvular (UV), pharyngeal/epiglottal (PH/E), and glottal (GL) consonant phonemes are presented.[1] In cases where the phonemic inventories of a language could not be found, the language is still listed as part of the stock being presented, but the space for the inventory is occupied by two long dashes (— —).[2] Phonemes in parentheses are classified as somehow marginal in the source, and an explanatory footnote is provided whenever possible. Sounds in square brackets are allophones (including primary phonetic realizations), and are either meant to show that post-velar consonants exist as conditioned allophones or that there is a realization of a phoneme that is generally thought to be uncommon (e.g. a uvular affricate, [q͡χ]).

It should also be noted that the names of languages are those which occur in some scholarly works, and may not be speakers' preferred names for their own languages. This is particularly true for the Salish languages. Moreover, the distinction between languages and dialects is not always straightforward. In cases where it was unclear whether a variety was a language or dialect, what its standard name was, or how it was genealogically classified, this study deferred to the AUTOTYP database (Nichols and Bickel 2009) as an authority.

The geographic clusters identified in this typological survey and the stocks included in them are shown in the list below. A subsection in the text is devoted to each geographic area, and details on the extent of these areas and the languages in them are provided there. The geographic areas are presented starting from the Middle East and North Africa since the most well-known examples of post-velar consonants come from Semitic. The rough order following that is Africa, followed by Asia going from west to east and south to north, followed by the Americas from north to south.

1. *The Middle East and North Africa*: Semitic, Berber
2. *Greater Abyssinia to the Tanzanian Rift Valley*: Semitic, Cushitic
3. *The Kalahari Basin*: Kwadi-Khoe, Ju, Tuu
4. *The Caucasus*: Nakh-Daghestanian, Northwest Caucasian, Turkic, Indo-European
5. *Iranian Plateau*: Indo-European (Iranian)
6. *Taiwan*: Austronesian ("Formosan")
7. *Southwestern Siberia*: Yeniseian, Turkic

[1]§4.4.2.1 discusses in detail how proposed distinctions between pharyngeal and epiglottal consonants are not place-based, but manner-based. Thus, the pharyngeal and epiglottal places are never contrastive. In the text, therefore, these consonants are simply referred to as "pharyngeal." Where a sound is specifically symbolized as epiglottal, this symbolism is retained.

[2]This is not done for the Iranian languages due to the questionable status of linguistic varieties as languages or dialects. Instead, only the languages for which data could be found are shown.

8. *The Pacific North Coast of Asia*: Eskimo-Aleut, Chukotko-Kamchatkan, Turkic, Yukaghir, Tungusic, Nivkh
9. *The Pacific Northwest Coast of North America*: Wakashan, Salish, Chimakuan
10. *The Andes*: Quechua, Uru-Chipaya, Callawaya, Jaqi (Aymaran), Kunza, Alacalufan, Chon
11. *The Gran Chaco*: Guaicuru, Vilela, Mataco

### 2.2.1 The Middle East and North Africa

The Middle East and North Africa is perhaps the best-known geographic cluster of languages with post-velar consonants. This cluster spreads throughout Mesopotamia, the Levant, the Arabian Peninsula, and across North Africa, and is dominated by languages from two stocks, Semitic and Berber. The classification of Semitic follows that in Rubin (2008:80), and the presentation of the languages follows the tree there going from left to right and top to bottom. Only languages that are still spoken or that are recently extinct are included here. The Ethiopian Semitic languages are omitted here, and are instead presented in §2.2.2 (Greater Abyssinia to the Tanzanian Rift). Arabic dialects are grouped into roughly geographic dialect clusters, following the division described in Rubin (2008:67).

The listing and grouping of Berber dialects follows Kossmann (1999:26-29). In many (if not all) the Berber dialects, /q/ is a marginal phoneme. For Tamashek, Heath (2005:25) states that "*q* is common as a phonetic entity but has marginal phonemic status." The uvular stop /q/ occurs in borrowings from Arabic and as a simplification of geminate /qː/, which itself is the geminate counterpart of /ʁ/. In addition, labialization and gemination are often phonemic. In Tashlhiyt Berber, labialization is phonemically distinctive on velar and uvular obstruents, and every single consonant in the inventory without exception can appear as geminate (Ridouane 2008:323). The primary pharyngeal/epiglottal consonants are also marginal throughout Berber. "The majority of words with a pharyngeal consonant ħ or ʕ are borrowed from Arabic" (Kossmann 2000:246; translation by JCS). In the few cases where this is not true, the words often have an expressive meaning and are rarely found in more than one dialect (ibid.). Kossmann provides examples of six or seven words that do not have an expressive meaning and are found in more than one dialect (246-248).

Finally, in both Arabic and Berber, there is a (non-identical) set of phonemically "emphatic" coronal consonants, which are phonetically uvularized.[3] While these are often phonologically grouped with at least some of the post-velar consonants, they will not be listed in the inventories presented here. The core set of "emphatics" in Arabic is /tˤ, dˤ, sˤ, zˤ/ (Watson 2002:273) and the core set in Berber is /dˤ, tːˤ, zˤ, zːˤ/ (Kossmann 2000:249).[4,5] Both Arabic and Berber have

[3]For a detailed explanation of the phonetics of these consonants, see Watson (2002:269-270), summarized here in §3.2.2.

[4]Although the "emphatics" are phonetically uvularized, they are considered to mark phonological post-velarization or pharyngealization. In Arabist literature, they are marked with a dot beneath, e.g. *ṭ*. Here, they are marked with a superscript /ʕ/ (as, for example, *tˤ*) following the convention in linguistics, which connects "emphasis" harmony with pharyngealization harmony in other languages.

[5]/tt/ is the geminate realization of /d/ (Kossmann 2000:249).

secondary sets that vary by dialect. The secondary set in Arabic is /bˤ, mˤ, lˤ, rˤ/, which are secondary because of their different behavior in emphasis spreading (Watson 2002:275). Berber's set is secondary by virtue of the segments being borrowed from Arabic. The secondary set in Berber usually includes at least /sˤ, lˤ/ (as in Tamashek; Heath 2005:24), but sometimes also includes /rˤ/, as in Kabyle (Naït-Zerrad 2001).

Table 2.1 presents the languages of the West Semitic branch of the Semitic stock, and Table 2.2 presents the languages of the Berber stock.

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| MODERN SOUTH ARABIAN | | | | | |
| Mehri | k, k', g, x, ɣ | | (ʕ)[6], ħ | ʔ, h | Rubin (2010:13-16) |
| Ḥarsūsi | k, k', g, x, ɣ | | (ʕ), ħ | ʔ, h | Johnstone (1977:xii-xiii) |
| Baṭḥari | k, k', g, x, ɣ | | ʕ, ħ | ʔ, h | Simeone-Senelle (1997:381-385) |
| Hobyōt | k, k', g, x, ɣ | | ʕ, ħ | ʔ, h | Simeone-Senelle (1997:381-385) |
| Jibbāli | k, k', gʲ, x, ɣ | | ʕ, ħ | ʔ, h | Johnstone (1981:xiii-xiv) |
| Soqoṭri | k, k', g, x, ɣ | | ʕ, ħ | ʔ, h | Simeone-Senelle (1997:381-385) |
| CENTRAL SEMITIC | | | | | |
| ARABIC DIALECT GROUPS | | | | | |
| Arabian Peninsular | k, g | χ, ʁ, | ʕ, ħ | h | Ingham (1994:13-15; Najdi dialect) |
| Mesopotamian | k, g, x, ɣ | q | ʕ, ħ | ʔ, h | Erwin (2004:3; Iraqi dialect) |
| Syro-Palestinian | k | q, χ, ʁ | ʕ, ħ | ʔ, h | Herzallah (1991:26-29; Palestinian dialect) |
| Egyptian | k, g, x, ɣ | | ʕ, ħ | ʔ, h | Watson (2002:20; Cairene dialect) |

[6] In Mehri and Ḥarsūsi, "generally, the pharyngeal is replaced by the laryngeal [ʔ], or is only but a virtual phoneme influencing the length and the timbre of the vowel in contact, sometimes inducing a diphthong" (Johnstone 1977:xii-xiii).

| | | | | | |
|---|---|---|---|---|---|
| Maghrebine (North African) | k, g, x, ɣ | | ʕ, ħ | ʔ, h | Owens (1984:5-9; Eastern Libyan dialect) |
| Maltese Arabic | k, g | | ħ | ʔ | Borg and Azzopardi-Alexander (1997:299) |
| | | NORTHWEST SEMITIC | | | |
| | | *Canaanite* | | | |
| Modern Hebrew | k, g, x | ʁ | | ʔ, h | Berman (1997:314) |
| | | *Aramaic Dialect Groups* | | | |
| Western Neo-Aramaic | k, x, ɣ | | ʕ, ħ | h | Jastrow (1997:334-335) |
| | | — Eastern Neo-Aramaic — | | | |
| Central Eastern Neo-Aramaic (Ṭuroyo, Mlaḥsô) | k, g, x, ɣ | q | ʕ, ħ | ʔ, h | Jastrow (1997:348-350) |
| Northern Eastern Neo-Aramaic | k, g, x, ɣ | q | | ʔ, h | Jastrow (1997:348-350) |
| Neo-Mandaic | k, g, x, ɣ | q | | ʔ, h | Jastrow (1997:348-350) |

Table 2.1: Inventory of velar and post-velar phonemes in the languages of the West Semitic branch of the Semitic stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| | | TUAREG | | | |
| Ahaggar | | — — | | | |
| Adagh des Ifoghas | | — — | | | |
| Tamashek (Mali) | k, g, ŋ | (q)[7], χ, ʁ | (ʕ), (ħ)[8] | (ʔ), h | Heath (2005:23) |
| Iwellemmeden (Niger) | k, g | (q/qː), χ, ʁ, ɴ[9] | | h | Prasse et al. (1998:vii-xv) |

[7] Usually occurs as the realization of geminate /ʁː/ (Heath 2005:25). Geminate /ʁː/ is also realized as [qː].

[8] Both pharyngeals and the glottal stop are mainly confined to loanwords (Heath 2005:23).

[9] This is specifically called a uvular nasal in the source for both Iwellemmeden and Ayr (xii).

| | | | | | |
|---|---|---|---|---|---|
| Ayr (Niger) | k, g | (q/qː), χ, ʁ, ɴ | | h | Prasse et al. (1998:vii-xv) |
| | | Ghadamès-Augila | | | |
| Ghadamès | | — — | | | |
| Augila | | — — | | | |
| | | Non-Zénète | | | |
| Kabyle | k, g | q, χ, ʁ | (ʕ), (ħ)[10] | h | Naït-Zerrad (2001:15-) |
| Tashlhiyt | k, $k^w$, g, $g^w$ | q, $q^w$, χ, $χ^w$, ʁ, $ʁ^w$ | ʢ, ʜ | h | Ridouane (2008:323)[11] |
| Senhaja (Sraïr) | k, g | q, χ, ʁ | ʕ, ħ | h | Ibanez (1959:xvi-xvii) |
| | | Zénète | | | |
| Rifain | k, g, | q, χ, ʁ | ʕ, ħ | h | Kossmann (2000:9) |
| Aït Segrouchen | k, g | q, χ, ʁ | ʕ, ħ | ʔ, h | Abdel-Massih (1971:4) |
| South Oranais (Figuig) | | — — | | | |
| Northwest Algerian | | — — | | | |
| Mzab | k, g | q, χ, ʁ | ʕ, ħ | h | Delheure (1984:xxiii) |
| Ouargla | k, g | q, χ, ʁ | ʕ, ħ | h | Delheure (1987:3-13) |
| Chaouia of Aurès | | — — | | | |
| Zuara | | — — | | | |
| Metmata | | — — | | | |
| | | Eastern | | | |
| Elfoqaha | | — — | | | |
| Nafusi | | — — | | | |
| Siwa | | — — | | | |
| | | Zenaga | | | |

[10] The pharyngeals occur only in borrowings from Arabic (Naït-Zerrad 2001:23).

[11] Every consonant in the inventory, including what are labeled the “aryepiglottals,” can be geminated (Ridouane 2008:323).

| | | | | | |
|---|---|---|---|---|---|
| Zenaga | k, g, x, ɣ, ŋ | q, χ, ʁ | (ʕ), (ħ)[12] | h | (Nicolas 1953:19-21) |

Table 2.2: Inventory of velar and post-velar phonemes in the languages/dialects of the Berber stock

### 2.2.2 Greater Abyssinia to the Tanzanian Rift Valley

The geographic cluster labeled here as Greater Abyssinia to the Tanzanian Rift Valley includes two areas that are usually treated as distinct: Greater Abyssinia and the Tanzanian Rift Valley (Kiessling et al. 2007).[13] These two areas are treated together here because languages from the Cushitic stock figure largely in both. While the Tanzanian Rift Valley is considered to be a salient linguistic area with definable characteristics in Kiessling et al. (2007), it is combined with Greater Abyssinia because there are few languages in that area that contain guttural consonants and most of those are Cushitic (with the possible exception of Datooga, a Nilotic language).

It has been argued that Ethiopia should be considered a Sprachbund (Ferguson 1970, Ferguson 1976, but cf. Tosco 2000), and moreover that having a pharyngeal fricative is a feature of that Sprachbund (Crass 2002). The present survey does not support that claim because it shows that the pharyngeal consonants are mostly restricted to identifiable subgroups in stocks in which primary pharyngeal consonants are commonly reconstructed. In the Ethiopic branch of Semitic, the North Ethiopic subgroup retains primary pharyngeal consonants. In the Cushitic stock, all of the Southern subgroup's languages retain pharyngeals while only some of the Eastern subgroup's languages do. The fact that only one subgroup of one out of the two main stocks in the area does not categorically retain or lose pharyngeal consonants indicates that the distribution of pharyngeal consonants can be characterized in a genealogical rather than areal way. The larger question of whether Ethiopia constitutes a Sprachbund is outside the scope of this work.

One Omotic language, Hamer, has a uvular ejective, /q'/, and a dominant-recessive system of vowel harmony in which pharyngealization seems to differentiate two sets of vowels (Lydall 1976). The Omotic languages, however, are not presented in a separate table since, apart from Hamer, only Aari has a phonemic guttural consonant, /q/ (Hayward 1990:429).

The classification of the Ethiopic Semitic languages is based on Hetzron (1972) as described in Rubin (2008:92), and these languages are presented in Table 2.3. The classification of the Cushitic languages is that of the AUTOTYP database (Nichols and Bickel 2009) and the subgroups and languages are presented alphabetically in Table 2.4.

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| NORTH ETHIOPIC | | | | | |

[12]The pharyngeals occur only in loanwords from Arabic (Nicolas 1953:19-20).

[13]The term "Greater Abyssinia" is from the AUTOTYP database (Nichols and Bickel 2009).

| | | | | | |
|---|---|---|---|---|---|
| Ge‘ez† | k, $k^w$, k’, $k^w$’, g, $g^w$, x, $x^w$ | | ʕ, ħ | ʔ, h | Gragg (1997:244) |
| Tigré | k, k’, g | | ʕ, ħ | ʔ, h | Raz (1997:447) |
| Tigrinya | k, $k^w$, k’, $k^w$’, g, $g^w$ | [χ, $χ^w$] | ʕ, ħ | ʔ, h | Kogan (1997:424) |
| SOUTH ETHIOPIC | | | | | |
| TRANSVERSAL SOUTH ETHIOPIC | | | | | |
| Amharic | k, $k^w$, k’, $k^w$’, g, $g^w$ | | | [ʔ], h, $h^w$ | Leslau (1995:4-5) |
| Argobba | k, $k^w$, k’, $k^w$’, g, $g^w$ | | | ʔ, h | Leslau (1959:251) |
| Harari | k, k’, g, x | | ħ | ʔ | Wagner (1997:487) |
| East Gurage | | | | | |
| Silte | k, k’, g | | | ʔ, h | Gutt (1983:38) |
| Inneqor (Azarnat) | — — | | | | |
| Wolane | — — | | | | |
| Zway | $k^j$, k’, g | | | ʔ, h | Leslau (1999:1) |
| OUTER SOUTH ETHIOPIC | | | | | |
| Gafat | k, $k^w$, k’, $k^w$’, g, $g^w$ | | | h, $h^w$ | Leslau (1956:1) |
| *Northern Gurage* | | | | | |
| Soddo | k, $k^w$, $k^j$, k’, $k^w$’, $k^j$’, g, $g^w$, $g^j$, x, $x^w$, $x^j$ | | | [ʔ], [$ʔ^w$] | Hetzron (1977:3-6,37-41) |
| Gogot | k, $k^w$, $k^j$, k’, $k^w$’, $k^j$’, g, $g^w$, $g^j$, x, $x^w$, $x^j$ | | | [ʔ], [$ʔ^w$] | Hetzron (1977:3-6,37-41) |
| Muher | k, $k^w$, $k^j$, k’, $k^w$’, $k^j$’, g, $g^w$, $g^j$, x | | | [ʔ], [$ʔ^w$] | Leslau (1981:6), Hetzron (1977:38) |
| *Western Gurage* | | | | | |
| Mäsqan | k, $k^w$, $k^j$, k’, $k^w$’, $k^j$’, g, $g^w$, $g^j$, x, $x^w$, $x^j$ | | | | Hetzron (1977:3-6,37-41) |
| Central West Gurage | | | | | |

| | | | |
|---|---|---|---|
| Chaha | k, $k^{w}$, $k^{j}$, k’, $k^{w}$’, $k^{j}$’, g, $g^{w}$, $g^{j}$, x, $x^{w}$, $x^{j}$ | h | Leslau (1983:8-9) |
| Ezha | k, $k^{w}$, $k^{j}$, k’, $k^{w}$’, $k^{j}$’, g, $g^{w}$, $g^{j}$, x, $x^{w}$, $x^{j}$ | | Hetzron (1977:3-6,37-41) |
| Gumer | k, $k^{w}$, $k^{j}$, k’, $k^{w}$’, $k^{j}$’, g, $g^{w}$, $g^{j}$, x, $x^{w}$, $x^{j}$ | | Hetzron (1977:3-6,37-41) |
| Gura | k, $k^{w}$, $k^{j}$, k’, $k^{w}$’, $k^{j}$’, g, $g^{w}$, $g^{j}$, x, $x^{w}$, $x^{j}$ | | Hetzron (1977:3-6,37-41) |
| | Peripheral West Gurage | | |
| Gyeto | k, $k^{w}$, $k^{j}$, k’, $k^{w}$’, $k^{j}$’, g, $g^{w}$, $g^{j}$, x, $x^{w}$, $x^{j}$ | ʔ | Hetzron (1977:3-6,37-41) |
| Inor (Ennemor) | k, $k^{w}$, $k^{j}$, k’, $k^{w}$’, $k^{j}$’, g, $g^{w}$, $g^{j}$, x, $x^{w}$, $x^{j}$ | ʔ, $ʔ^{w}$, h | Leslau (1983:8-9) |
| Enär | k, $k^{w}$, $k^{j}$, k’, $k^{w}$’, $k^{j}$’, g, $g^{w}$, $g^{j}$, x, $x^{w}$, $x^{j}$ | ʔ, $ʔ^{w}$ | Hetzron (1977:3-6,37-41) |
| əndägäɲ | k, $k^{w}$, k’, $k^{w}$’, $k^{j}$’, g, $g^{w}$, $g^{j}$, x, $x^{w}$ | ʔ, $ʔ^{w}$ | Hetzron (1977:3-6,37-41) |

Table 2.3: Inventory of velar and post-velar phonemes in the languages of the Ethiopic Branch of the Semitic stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| | | CENTRAL CUSHITIC (AGAW) | | | |
| Awngi | k, $k^{w}$, g, $g^{w}$, ŋ, $ŋ^{w}$ | q, $q^{w}$, ɢ, $ɢ^{w}$ | | | Hetzron (1969:4-5) |
| Bilin | | — — | | | |
| Kemantney | k, $k^{w}$, g, $g^{w}$, x, $x^{w}$, ɣ, $ɣ^{w}$, ŋ, $ŋ^{w}$ | | | | Leyew (2003:158) |
| | | EASTERN CUSHITIC | | | |

| | | | | | |
|---|---|---|---|---|---|
| Arbore | k, k’, g, ŋ, w | | | ʔ, h | Hayward (1984:51) |
| Bayso | k, k’, g | | | ʔ, h | Hayward (1978:541) |
| Burji | k, k’, g | | | ʔ, h | Sasse (1982:15) |
| Dhaasanac | k, g, ɠ, ŋ | [q] | | ʔ | Tosco (2001:17) |
| Dullay (Gawwada dialect) | k, k’, x | q | ʕ, ħ | ʔ | Black (1976:224) |
| Kambaata | | — — | | | |
| Oromo (Harar) | (k), k’, g, x | | | ʔ, h | Owens (1985:10) |
| Oromo (Boraana) | k, k’ | | | h | Stroomer (1995:7) |
| Oromo (Waata) | k, g, k’ | [q] | | ʔ, h | Heine (1981:21) |
| Oromo (West-Central) | k, k’, g | | | ʔ, h | Gragg and Kumsa (1982:xviii) |
| Qafar (Afar) | k, g | | ʕ, ħ | h | Parker and Hayward (1985:214) |
| Rendille | k, g, x, ŋ | q/ɢ | ʕ, ħ | ʔ, h | Pillinger and Galboran (1999:8-10) |
| Saho | | — — | | | |
| Somali | k, g | q/ɢ [q͡ʡ], χ | ʕ [ʡ͡ʕ], ʜ | ʔ, h | Saeed (1999:7), Edmondson et al. (2004:5-6) |
| Southern Cushitic | | | | | |
| Alagwa | | — — | | | |
| Burunge | k, $k^w$, g, $g^w$, x, $x^w$, ŋ | q, $q^w$ | ʕ, ħ | ʔ, h | Kiessling (1994:15,19-22) |
| Dahalo | k, $k^w$, k’, $k^w$’, g, $g^w$, $^{ŋ}g$, $^{ŋ}g^w$ | | ʕ, ħ | ʔ, h | Tosco (1991) |
| Iraqw | k, $k^w$, g, $g^w$, x, $x^w$, ŋ, $ŋ^w$ | q [q͡χ] | ʡ, ħ | ʔ, h | Nordbustad (1988:6-13), Mous (1993:15-18) |
| Mixed (Bantu & Southern Cushitic) | | | | | |
| Ma’a (Mbugu) | k, $^{ŋ̊}k$, g, $^{ŋ}g$, x, $^{ŋ̊}x$, ɣ, ŋ | | | h | Mous (2003:95-97) |

Table 2.4: Inventory of velar and post-velar phonemes in the languages of the Cushitic stock

### 2.2.3 The Kalahari Basin

The following inventories present the languages and stocks that form part of the Kalahari Basin cluster. The Kalahari Basin has been identified as a possible residual zone by Güldemann (1997). Most of the languages in this cluster were formerly considered "Khoisan," but that grouping, originally proposed by Greenberg (1963), has been rejected (Honken 2013b). That grouping originally included Hadza and Sandawe, which are now thought to be isolates and which are not in the Kalahari Basin, but near the Tanzanian Rift Valley.

The classification used here follows that of Güldemann (2006).[14] In the following inventories, the abbreviation "(d.c.)" beside a language name means that it is a dialect cluster or continuum. The phoneme /k'/ is realized as such in some languages, but in many, it historically developed into the affricate /k͡x'/ and is transcribed as such. The plain affricate /k͡x/ also exists in some languages, and where the velar phonemes /k'/, /k͡x/, or /k͡x'/ appear in parentheses, the parenthesized variant occurs in words borrowed from nearby languages that have those sounds in their inventories.

The Kalahari Basin languages that originally formed part of the "Khoisan" family are rich in phenomena relevant to post-velar articulations. Uvular consonants are common, and in many languages, the uvular series is elaborated on par with the velar series. The number of uvular consonants may even surpass that of the velars, as in G|ui (Nakagawa 2010:28) and West !Xõo (Naumann Forthcoming:4). In addition, when the click consonants occur in clusters, they occupy the first part of the cluster and the sounds that can form the second part of the cluster are limited to uvulars and glottals. This distribution is apparent in G|ui, !Xõo, and Ju|'hoan (Nakagawa 2006:249,267,279). In addition, some of the languages contrast modal and pharyngealized vowels. For example, East !Xõo contrasts modal and pharyngealized vowels, and in addition allows pharyngealized vowels to surface as simply pharyngealized, pharyngealized and creaky, or pharyngealized and nasalized (and in one case also pharyngealized and breathy, or "strident"; Traill 1985:68).

The inventories of click consonants in languages of the Kalahari Basin are often extremely large.[15] The phonetic characteristics of many of these clicks cannot be captured by using only the IPA symbols for clicks (ʘ, !, |, ǂ, ‖), and some of these can be analyzed as being voiced, ejective, or aspirated. These are usually grouped with voiced, ejective, and aspirated stops, and are called "complex" clicks (Nakagawa 2006:267). However, there are still other clicks that need a more elaborate description. These additional clicks can be analyzed under either a unit analysis or a cluster analysis (ibid.:250). Under a unit analysis like the type advocated in Miller-Ockhuizen (2003), the feature that distinguishes these more elaborate clicks is release type. Miller-Ockhuizen

[14]Thank you to Tom Güldemann for allowing the use of notes from two classes he taught in Berlin in 2009, *Eine Einführung in die Khoisanistik* and *Die !Ui-Sprachen (Tuu alias 'Südkhoisan')*. These notes are cited as "Güldemann p.c." Many thanks also to Florian Lionnet for supplying me with those notes and providing helpful advice and discussion on the phonetic and phonological aspects of these languages.

[15]The proceeding description and classification of click types follows that embodied in Tom Güldemann's class notes and in Nakagawa (2006: ch. 5).

proposes both uvularized and epiglottalized clicks under the unit analysis. However, under a cluster analysis, what Miller-Ockhuizen classifies as uvularized clicks are instead classified as clusters of a click followed by the uvular fricative [χ], and epiglottalized clicks are analyzed as clusters of a click followed by [q͡χ’] (Nakagawa 2006:276-278). Nakagawa’s Moderate Cluster Analysis (ibid.:250) is adopted for interpreting the sources for the inventories presented below since it represents the majority opinion among Khoisanists. The tables below present the language of the Khoe-Kwadi, Ju, Hõa, and Tuu stocks,in that order.

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Kwadi† | k, k(x)$^h$, k(x)’, g, x, ŋ | | | ʔ, h | Güldemann (2013a:87) |
| | | KHOE | | | |
| | | KALAHARI | | | |
| | | *West* | | | |
| Khwe | k, k$^j$, k$^h$, k$^{hj}$, k͡x’, g, g$^j$, x, ɣ, ŋ, $^ŋ$g | q | | ʔ, h | Vossen (2013a:59) |
| Buga | k, k$^h$, k͡x’, g, x, ɣ, ŋ, $^ŋ$g | q | | ʔ, h | Vossen (2013a:59) |
| ‖Ani (d.c.) | k, k$^h$, k͡x’, g, x, ɣ, ŋ | q | | ʔ, h | Vossen (2013a:59) |
| Naro (d.c.) | k, k$^h$, k͡x, k͡x’, g, x | | | ʔ, h | Visser (2013:61) |
| G‖ana | k, k$^h$, k’, (k͡x)[16], k͡x’, g, ŋ | q, q$^h$, q’, ɢ, χ | | ʔ, h | Nakagawa (2013:69) |
| G\|ui | k, k$^h$, k’, g | q, q$^h$, q’, ɢ, q͡χ’, χ | | ʔ, h | Nakagawa (2010:28) |
| ǂHaba (d.c.) | | —— | | | |
| | | *East* | | | |
| Shua | k, k$^h$, k’, g, x, ŋ, $^ŋ$g | | | ʔ, h | Vossen (2013b:71) |
| Ts’ixa | k, k$^h$, k’, k͡x’, g, x, ŋ, $^ŋ$g | | | ʔ, h | Vossen (2013b:71) |
| Danisi | k, k$^h$, k’, k͡x’, g, x, ŋ, $^ŋ$g | | | ʔ, h | Vossen (2013b:71) |
| \|Xaise | k, k$^h$, k’, g, x, ŋ, $^ŋ$g | | | ʔ, h | Vossen (2013b:71) |

[16]Occurs only in the Thomelo dialect of G‖ana.

| | | | | | |
|---|---|---|---|---|---|
| Deti† (d.c.) | k, $k^h$, k’, g, x, ŋ, $^{ŋ}$g | | | ʔ, h | Vossen (2013b:71) |
| Kua-Tsua (d.c.) | k, $k^h$, k’, g, x, ŋ, (ŋg)[17] | q | | ʔ, h | Vossen (2013c:74) |
| | | KHOEKHOE | | | |
| | | *North* | | | |
| Eini† | | — — | | | |
| Nama-Damara | k, $k^h$, (k͡x), k͡x’, x | | | ʔ, h | Haacke (2013:54) |
| Hai‖’om | | *— very similar to Nama-Damara —* | | | Widlok (2013:56-58) |
| ǂAakhoe (d.c.) | | *— very similar to Nama-Damara —* | | | Widlok (2013:56-58) |
| | | *South* | | | |
| !Ora† (d.c.) | k, $k^h$, k͡x’, g, x | | | ʔ, h | Haacke (2013:54) |
| Cape Khoekhoe† (d.c.) | | — — | | | |

Table 2.5: Inventory of velar and post-velar phonemes in the languages of the Khoe-Kwadi stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| | | NORTHWEST | | | |
| !’O!Xũu | | — — | | | |
| !Xũu | | — — | | | |
| | | SOUTHEAST | | | |
| Ju\|’hoan | k, $k^h$, g, g$^{ɦ}$, ŋ | χ | | ʔ, h | Miller (2013:50), Miller-Ockhuizen (2003) |
| ǂKx’au‖’en | | — — | | | |

Table 2.6: Inventory of velar and post-velar phonemes in the languages of the Ju stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| ǂHõa | k, $k^h$, (k’), k͡x’, g, x | q, $q^h$, q’, $^{N}$q | | ʔ, h | Honken (2013a:85; Eastern dialect) |

[17] Occurs only in Kua.

Table 2.7: Inventory of Velar and Post-Velar Phonemes in ǂHõa

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| | | TAA - LOWER NOSSOB | | | |
| | | *Taa* | | | |
| East !Xõo | k, k$^h$, k(x)', g, g͡x, g͡x$^ʔ$ | q, q$^h$, q', ɢ, ɢ$^h$ | | ʔ, h | Güldemann p.c. following Traill (1985) and Traill and Vossen (1994) |
| West !Xõo (d.c.) | k, k$^h$, k', g, g$^h$, g$^ʔ$, ŋ | q, q$^h$, q', q͡χ', ɢ, ɢ$^h$, ɢ$^ʔ$, ɢ͡ʁ$^ʔ$, χ | | ʔ, h | Naumann (Forthcoming:4) |
| | | *Lower Nossob* | | | |
| \|'Auni† | | —— | | | |
| \|Haasi† | k, k$^h$, k͡x', g, x, ŋ | q | | ʔ, h | Güldemann (2013b:81) |
| | | !UI | | | |
| \|Xam† (d.c.) | k, k$^h$, k', k͡x, k͡x', g, x, ŋ | q, q$^h$, q', ɢ | | ʔ, h, ɦ | Güldemann (2013b:82) |
| | | *N‖ng* | | | |
| N\|uu | k, k$^h$, k͡x', g, ŋ | q, q͡χ', χ | | (ʔ), (ɦ) | Miller et al. (2007:106) |
| ǂUngkue† | k, k$^h$, k͡x', g, x, ŋ | | | ʔ, h | Güldemann p.c. |
| ‖Xegwi† | k, k$^h$, k$^w$', k͡x, k͡x', g, x, ŋ | q, q$^h$, q', ɢ | | ʔ, h, ɦ | Güldemann p.c. following Lanham and Hallowes (1956) |

Table 2.8: Inventory of velar and post-velar phonemes in the languages of the Tuu stock

## 2.2.4 The Caucasus

The languages of the Caucasus are well-known for their extensive consonant inventories. The Caucasus is located between the Black and Caspian Seas and north of Turkey and Iran, which separate it from the Middle East and North Africa.[18] The consonant inventories of languages spoken south

[18] A useful linguistic map of the Caucasus region created in 2012 by Asya Pereltsvaig and Jake Coolidge can be found at:

of the main Caucasus range are more restricted than those of languages to the north, but still contain post-velar consonants. Every language of the Caucasus in the Nakh-Daghestanian, Northwest Caucasian, and Kartvelian stocks has a contrast between the velar and uvular places of articulation, and most of the languages also contrast the pharyngeal/epiglottal and glottal places of articulation. Ubykh, Abaza, and Abkhaz are notable for having palatalized uvular stops and fricatives (/$q^j$', $\chi^j$, $ʁ^j$/, with /$q^j$/ only occurring in Ubykh). Palatalized uvular consonants are extremely rare and appear to flout the tendency for avoiding co-occurring palatal/front and guttural articulations. Another rare type of consonant that is well represented in the Caucasus are pharyngealized uvular consonants, which occur in Khwarshi, Tsez, Rutul, Tsakhur, Ubykh, Abaza, and Abkhaz.

The following tables show the inventories of languages in the Caucasus region. The Nakh-Daghestanian (Northeast Caucasian) languages are presented first, followed by the Northwest Caucasian languages, followed by the Kartvelian (South Caucasian) languages. After presenting these stocks, which are found only in the Caucasus region, the Turkic and Indo-European languages spoken in the Caucasus area are presented.[19] Given the fact that Turkic is not reconstructed with uvulars and most Indo-European languages no longer contain uvulars, the occurrence of contrastive uvulars in their phonemic inventories in the Caucasus region could be the result of intense contact with the three stocks found only in the Caucasus.[20]

The identification of languages and their subgroupings for the three stocks found only in the Caucasus follows that of the AUTOTYP database (Nichols and Bickel 2009). The ordering of the subgroupings follows Figure 1 of Nichols (2003:207). The primary source for the Northwest Caucasian languages is Colarusso (1988). The classification of the Turkic languages follows that given in Johanson (1998:82-83), supplemented by information from AUTOTYP. The Indo-European languages are classified according to AUTOTYP.

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| | | NAKH | | | |
| | | VAINAKH | | | |
| Chechen | k, k', g, x | q, q', ʁ | ʡ, ħ | ʔ, h | Nichols and Vagapov (2004:21) |
| Ingush | k, k', g, x | q, qː, q', ʁ | ʡ, ħ | ʔ, h | Nichols (2011:20) |
| | | TSOVA-TUSH | | | |

http://www.geocurrents.info/wp-content/uploads/2012/07/CaucasusLayout_rev2July2012.png.

[19] These three stocks, Nakh-Daghestanian, Northwest Caucasian, and Kartvelian, are usually considered to be the "indigenous" stocks of the Caucasus. However, languages such as Armenian and Azerbaijani, which must have been introduced into the Caucasus given the proposed homelands of their stocks, have a very long history in the Caucasus and are so deeply rooted in it that excluding them from the category "indigenous" may be appropriate on historical linguistic grounds, but is otherwise extremely questionable.

[20] Natural historical developments, possibly independent of contact pressure, may have given rise to the uvulars, as happened with Shekgalagari in the Kalahari Basin (Solé et al. inventory in 2010:606; Hyman, p.c. on the origin of uvulars in the language).

| | | | | | |
|---|---|---|---|---|---|
| Tsova-Tush | k, k’, g, x, xː, ɣ | q, q’, qː, q’ː | ʡ, ħ | ʔ, h | Holisky and Gagua (1994:150) |
| | | DAGHESTANIAN | | | |
| | | AVAR-ANDIC | | | |
| Avar | k, k͡xː, k’, k͡xː’, g | q, q’, χ, χː, ʁ | ʕ, ħ | (ʔ), h | Charachidzé (1981:28) |
| | | *Andic* | | | |
| Akhvakh | k, kː, k’, k’ː, g, x, xː, ɣ | q͡χ, q͡χː, q͡χ’, q͡χː’, (ɢ) | ʕ, ħ | ʔ, h | Magomedbekova (1967:337) |
| Andi | k, kː, k’, k’ː, g, x, xː, ɣ | q͡χ, q͡χ’, q͡χː’ | ʕ, ħ | ʔ, h | Cercvadze (1967:277) |
| Bagvalal | k, kʷ, k’, k’ʷ, g, gʷ, x | q, qʷ, q’, q’ʷ, ʁ, ʁʷ, χ, χː, χʷ, χʷː | ʕ, ħ | ʔ, h, hʷ | Čumakina et al. (2001:41) |
| Botlikh | k, kː, k’, k’ː, g, x, xː, ɣ | q͡χ, q͡χ’ | ʕ, ħ | ʔ, h | Gudava (1967:294) |
| Chamalal | k, k’, g, x, (xː) | q͡χ, q͡χ’, χ, χː, ʁ | ʕ, ħ | ʔ, h | Magomedova (1999:413) |
| Godoberi | k, kː, k’, g, x, xː | q, q’, χ, χː, ʁ | ʡ, ħ | ʔ, h | Kibrik (1996:1) |
| Karata | k, k͡xː, k’, k͡xː’, x, xː, ɣ | q͡χ, q͡χ’ | ʕ, ħ | ʔ, h | Magomedbekova (1971:13) |
| Tindi | k, kː, kʲ, kʲː, k’, kʲ’, g, gʲ, xʲ, x | qː, q’, χ, χː, ʁ | ʕ, ħ | ʔ, h | Magomedova (2003:540)[21] |
| | | TSEZIC | | | |
| Bezhta | k, k’, g | q, q’, χ, ʁ | (ʕ), (ħ) | ʔ, h | Bokarev and Madieva (1967:456) |
| Hinukh | k, k’, g | q͡χ, q͡χ’, χ, ʁ | ʕ, ħ | ʔ, h | Xalilov and Isakov (2005:562) |
| Hunzib | k, k’, g, x | q, q’, χ, ʁ | ʕ, ħ | ʔ, h | van den Berg (1995:19)[22] |

[21] /ʕ, ħ, t͡s/, and /x/ occur primarily in loans from Avar (Magomedova 2003:541).

[22] "The phonemes /x/, /ħ/ and /ʕ/ are only found in loan words" which are described as coming primarily from Avar (van den Berg 1995:20).

| | | | | | |
|---|---|---|---|---|---|
| Khwarshi | k, kˤ, kʷ, k’, kˤ’, kʷ’, g, gˤ, gʷ, x | q͡χʰ, q͡χʰˤ, q͡χʰʷ, q͡χ’, q͡χ’ˤ, q͡χ’ʷ, q͡χ’ˤʷ, ʁ, ʁˤ, ʁʷ, ʁˤʷ, χ, χˤ, χʷ, χˤʷ | ʕ, ħ | ʔ, h, hˤ | Khalilova (2009:13-22; Kwantlada dialect) |
| Tsez | k, k’, g | q, qˤ, q’, qˤ’, χ, ʁ, ʁˤ | ʔ, ʜ | (ʔ), h | Maddieson et al. (1996:96) |
| LAK | | | | | |
| Lak | k, kː, k’, g, x, xː | q, qː, q’, χ, χː, ʁ | ħ | ʔ, h | Anderson (1997:978) |
| DARGIC | | | | | |
| (Literary) Dargi | k, k’, g, x | q, q’, ɢ, χ, ʁ | ʕ, ħ | ʔ, h | Abdullaev (1967:509) |
| Icari Dargi | k, kː, k’, ɣ, x, xː | q, qː, q’, χ, χː, ʁ | ʕ, ħ | ʔ, h | Sumbatova and Mutalov (2003:2) |
| Kubachi Dargi | k, kʷ, k’, g, x, xʷ | q, qʷ, q’, ʁ, χ, χʷ | ʕ, ħ | ʔ, h | Magometov (1963:46) |
| Meheb Dargi | k, kʷ, k’, k’ʷ, g, x, xʷ, ɣ | q, qʷ, q’, q’ʷ, χ, χʷ, ʁ | ʕ, ħ, ħː | ʔ, h | Magometov (1982:8-25) |
| LEZGIAN | | | | | |
| Archi | kʰ, kʰʷ, kː, kʷː, k’, k’ʷ, g, gʷ | q, qʷ, q’, q’ʷ, qː’, χ, χʷ, χː, χʷː, ʁ, ʁʷ | ʔ, ħ | ʔ, h | Kibrik et al. (1977:224) |
| Udi | k, k’, g, x, ɣ | q, q’ | | h | Harris (2002:xiv-xv) |
| *Samurian (Core Lezgian)* | | | | | |
| Eastern Samurian | | | | | |
| Rutul | k, kʷ, k’, k’ʷ, g, gʷ, x, xʷ, ɣ | q, qʷ, qˤ, qˤʷ, q’, q’ʷ, qˤ’, qˤʷ’, ɢ, ɢˤ, ɢʷ, ɢˤʷ, χ, χˤ, χʷ, χˤʷ, ʁ, ʁʷ, ʁˤ | ʔˤ, hˤ | ʔ, h | Ibragimov (1978:22; Muxad dialect) |

| | | | | | |
|---|---|---|---|---|---|
| Tsakhur | k, kʷ, kː, k’, k’ʷ, g, gʷ, x, xʷ, xː, xʷː, ɣ | q, qʷ, qˤ, qː, qʷː, qˤː, q’, qʷ’, qˤ’, qˤʷ’, ɢ, ɢʷ, ɢˤ, χ, χʷ, χˤ, χˤʷ, χː, χˤː, ʁ, ʁˤ, ʁʷ, ʁˤʷ | ʔˤ, hˤ | ʔ, h, hʷ | Ibragimov (1990:26; Tsax dialect) |
| Southern Samurian | | | | | |
| Budukh | k, k’, g, x | q, q’, χ, ʁ | ʡ, ʕ, ħ | ʔ, h | Talibov (2007:35), Alekseev (1994a:261-262)[23] |
| Kryz | kʰ, kʷ, kʲ, k’, kʷ’, kʲ’, g, gʷ, x, ɣ | qʰ, qʷ, q’, qʲ’, qʷ’, ɢ, χ | ʕ | ʔ, h | Authier (2009:11-15) |
| Western Samurian | | | | | |
| Agul | k, kʷ, kː, kʷː, k’, kʷ’, g, gʷ, x, xː | q, qʷ, qː, qʷː, q’, qʷ’, χ, χʷ, χː, ʁ, ʁʷ | ʡ, ([ʜ])[24], ʕ, ħ | ʔ, h | Magometov (1970:18-32), Maisak (2008) |
| Lezgi | k, kʷ, kʰ, kʰʷ, k’, kʷ’, g, gʷ, x | q, qʷ, qʰ, qʰʷ, q’, qʷ’, χ, χʷ, ʁ, ʁʷ | | ʔ, h | Haspelmath (1993:2, 34) |
| Tabassaran | kʰ, kʰʷ, k, kʷ, k’, kʷ’, g, gʷ, x, ɣ | q͡χʰ, q͡χʰʷ, q͡χ, q͡χʷ, q͡χ’, q͡χʷ’, χ, χʷ, ʁ, ʁʷ | | ʔ, h | Alekseev and Šixalieva (2003:29) |
| XINALUG | | | | | |
| Xinalug | kʰ, kʲ, k, kʷ, k’, kʲ’, kʷ’, g, gʷ, x, ɣ | qʰ, q, qʷ, q’, qʷ’, χ, χʷ, ʁ, ʁʷ | ʡ, (ʕ), ħ | ʔ, h | Dešeriev (1967:660), Ganieva (2002:471) |

[23] Although Talibov (2007:35) lists [ɢ] as a phoneme, the sound “[i]s used in post-nasal consonant position,” (27) indicating that it is in fact an allophone of /q/ with a clear conditioning environment.

[24] Agul is somewhat famous for the claim that it motivates a phonemic contrast between pharyngeal and epiglottal consonants (Ladefoged and Maddieson 1996:, citing Sandro Kodzasov). The data cited in Ladefoged and Maddieson (1996) exhibits only near minimal pairs, and while this cannot be taken as proof that the consonants are not phonemically opposed, it is reason to question the contrast. Only certain dialects are claimed to contrast pharyngeal and epiglottal phonemes (namely Burščag, Riča, Burkikhan, but not Fite; Kibrik and Kodzasov 1990:338-341). The contrast also does not exist in the Huppuq’ dialect, and recent field research on Burkikhan failed to confirm the presence of the pharyngeal vs. epiglottal contrast there (Timur Maisak, p.c.).

Table 2.9: Inventory of velar and post-velar phonemes in the languages of the Nakh-Daghestanian stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| | | UBYKH | | | |
| Ubykh | kʲ, kʲ’, kʷ, kʷ’, gʲ, gʷ, x, (xʷ), ɣ | q, q’, qʲ, qʲ’, qʷ, qʷ’, qˤ, qˤ’, qˤʷ, qˤʷ’, χ, χʲ, χʷ, χˤ, χˤʷ, ʁ, ʁʲ, ʁʷ, ʁˤ, ʁˤʷ | | h | Colarusso (1988:438) |
| | | ABKHAZ-ABAZA | | | |
| Abaza | k, k’, kʲ, kʲ’, kʷ, kʷ’, g, gʲ, gʷ, x, xʷ | q’, qʲ’, qʷ’, qˤ, qˤʷ, χ, χʲ, χʷ, ʁ, ʁʲ, ʁʷ | ʕ, ʕʷ, ħ, ħʷ | ʔ | Colarusso (1988:448) |
| Abkhaz | k, k’, kʲ, kʲ’, kʷ, kʷ’, g, gʲ, gʷ | q’, qʲ’, qʷ’, χ, χʲ, χʷ, χˤ, χˤʷ, ʁ, ʁʲ, ʁʷ | ʕʷ, ħ, ħʷ | ɦ | Colarusso (1988:441; Bzyb dialect)[25] |
| | | CIRCASSIAN | | | |
| | | *West Circassian* | | | |
| Abadzakh Adyghe | kʷ, kʷ’, gʷ, x, xʷ, ɣ | q, qʷ, χ, χʷ, ʁ, ʁʷ | ħ | ʔ, ʔʷ, (h) | Colarusso (1988:428) |
| Shapsegh Adyghe | kʲ, kʲʰ, kʲ’, kʷ, kʷʰ, kʷ’, gʲ, gʷ, xʰ, x, ɣ | q, qʰ, qʷ, qʷʰ, χ, χʷ, ʁ, ʁʷ | ħ | ʔ, ʔʷ, (h) | Colarusso (1988:422) |
| Temirgoy Adyghe | kʷ, kʷ’, gʷ, x, xʷ, ɣ | q, qʷ, χ, χʷ, ʁ, ʁʷ | ħ | ʔ, ʔʷ, (h) | Colarusso (1988:426) |
| | | *East Circassian* | | | |
| Kabardian | kʲ, kʲ’, kʷ, kʷ’, gʲ, gʷ, x, xʷ, ɣ | q, q’, qʷ, qʷ’, χ, χʷ, ʁʷ | ʡ, ʜ | ʔ, ʔʷ, h | Colarusso (1992:10-12) |

[25] The Ashkharwa varieties (both Apsuy and Kuvin) have /qˤ, qˤʷ, ʕ/ in addition to all the other post-velar phonemes of Bzyb. The Anatolian variety of Abkhaz lacks pharyngealized uvulars altogether, and uses glottal /h/ in place of pharyngeal /ħ/, such that there is a minimal voicing distinction in the glottal fricatives opposing /h/ to /ɦ/ (Colarusso 1988:441-446).

Table 2.10: Inventory of velar and post-velar phonemes in the languages of the Northwest Caucasian stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Svan | k, k', g | q, q', χ, ʁ | | h | Schmidt (1991:476) |
| | | GEORGIAN-ZAN | | | |
| Georgian | $k^h$, k', g, x, ɣ | q' | | h | Shosted and Chikovani (2006:255) |
| | | *Zan* | | | |
| Laz | k, k', g | q', χ, ʁ | | h | Holisky (1991:398-401) |
| Mingrelian | k, k', g, x, ɣ | q' | | ʔ, h | Harris (1991:316-326) |

Table 2.11: Inventory of velar and post-velar phonemes in the languages of the Kartvelian stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| | | WEST KIPCHAK | | | |
| Karachay-Balkar | g, k, x, ŋ | q, χ, ʁ | | h | Xabičev (1966:215) |
| Kumyk | k, g, ŋ | q, χ, ʁ | | h | Magomedov (1966:196) |
| | | SOUTH KIPCHAK | | | |
| Nogai | k, g, ŋ | [q], χ, ʁ | | | Baskakov (1966b:282) |
| | | OGHUZ | | | |
| Azerbaijani | k, g, x, ɣ | | | h | Öztopçu (2000:8-10) |
| Urum | | — — | | | |

Table 2.12: Inventory of velar and post-velar phonemes in the languages of the Turkic stock in the Caucasus

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| | | ARMENIAN | | | |
| Standard Eastern Armenian | k, $k^h$, g | χ, ʁ | | h | Vaux (1998:12-16) |
| Standard Western Armenian | $k^h$, g | χ, ʁ | | h | Vaux (1998:16-21) |
| | | INDO-IRANIAN | | | |
| Judeo-Tat | | — — | | | |
| Ossetic | k, $k^w$, k’, $k^w$’, g, $g^w$ | q, $q^w$, χ, $\chi^w$, ʁ, $ʁ^w$ | | | Testen (1997:710) |
| Talysh | k, g | χ, ʁ | | h | Sokolova (1953:112-117) |
| Tat | k, g($^j$), x | q | (ʕ), (ħ) | h | Grjunberg (1966:284) |
| Kurdish[26] | k, $k^h$, g | q, χ, $\chi^w$, ʁ | ħ | h | Bakaev (1973:41-56) |

Table 2.13: Inventory of velar and post-velar phonemes in the languages of the Indo-European stock in the Caucasus

### 2.2.5 Iranian Plateau

The Iranian plateau region is considered here to be an “extensive mountain zone that extends from eastern Asia Minor and the Caucasus as far as the plains of the Punjab” and includes the entire state of Iran, Afghanistan, and the mountainous region of Pakistan (Fisher 1968:5).[27] The Iranian languages of the Indo-European stock are spread throughout this area.

[26]Specifically, these are the Kurmanji varieties spoken in the southern Caucasus, including Armenia and Azerbaijan. The pharyngeal consonant “is absent as a phoneme in the speech varieties [Rus. *govory*] of Kurds of Azerbaijan and Turkmenistan, but in words borrowed from Arabic it is sometimes encountered as the lower-pharyngeal [i.e. glottal; JCS] variant /h/. In the speech varieties of the Kurds of Armenia and in the literary language /ħ/ has a sufficiently wide distribution” (Bakaev 1973:50). Bakaev notes that the sound likely came in via Arabic words and then diffused into native Kurdish lexemes (ibid.). The phoneme /q/ came into all Kurdish dialects via borrowings from Arabic and Turkic languages (47-48).

[27]It must be noted that the author of this definition believed that the Iranian plateau constituted only “the inner central basins of the Iranian state” and that “there are no strong grounds for extending the connotation of “Iranian plateau” to include upland areas of Afghanistan and West Pakistan” despite the use of the term in that way “by several American and English writers” (Fisher 1968:5). Here, the geographic definition of the Iranian plateau is not of great consequence since it is mainly meant to represent an area that includes the Iranian languages of the Indo-European stock.

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| | | NORTHWEST IRANIAN | | | |
| Baluchi | k, g, (x)[28], ɣ | | | | Nawata (1981:3) |
| Chali | k, g | q, χ, $χ^w$ | | ʔ, h | Yar-Shater (1969:32-33) |
| Dari | k, g, x, ɣ | | | h | Farudi and Toosarvandani (2004:27) |
| Dimili | k, g, x, ɣ, w | | ʕ, ħ | h | Todd (2002:2) |
| Eshtehardi | k, g | q, χ | | | Yar-Shater (1969:43) |
| Gilaki | k, g | χ, ʁ | ʕ, ħ | h | Rastorgueva et al. (2012:14) |
| Kurdish (Central) | k, g, x, ɣ | q | ħ | h | Thackston (2006b:1) |
| Kurmanji | k, kʕ, g, χ, ɣ | q | ħ, ʕ | h | Thackston (2006a:2) |
| Parachi | k, $k^h$, g, $g^h$, x, ɣ | (q)[29] | | | Kieffer (2009:695) |
| Takestani | k, g | q, χ | | | Yar-Shater (1969:40) |
| | | SOUTHEAST IRANIAN | | | |
| Ishkashmi | k, g, x, ɣ | q | | | Edelman and Dodykhudoeva (2009:779) |
| Munji | k, g, x | (q), χ, ʁ | | | Edelman and Dodykhudoeva (2009:780) |
| Pashto | k, g, x, ɣ | (q)[30] | (ħ), (ʕ) | h, ʔ | Rodson and Tegey (2009:724) |
| Rushan | k, g, x, ɣ | q, χ, ʁ | | | Edelman and Dodykhudoeva (2009:779) |
| Sanglichi | k, g, x, ɣ | q, χ, ʁ | | | Edelman and Dodykhudoeva (2009:779) |

[28] This phoneme is found only in borrowings from Persian (Nawata 1981:3).
[29] This phoneme occurs only in borrowings (Kieffer 2009:695).
[30] These phonemes, /q, ħ, ʕ/, occur only in borrowings (Rodson and Tegey 2009:724).

| | | | | | |
|---|---|---|---|---|---|
| Shughni | k, g, x, ɣ | q, χ, ʁ | | | Edelman and Dodykhudoeva (2009:779) |
| Wakhi (Wakhan) | k, g, x, ɣ | q, χ, ʁ | | | Bashir (2009:827) |
| Yazgulyam | k, kʷ, x, xʷ, g, gʷ, ɣ | q, qʷ, χ, ʁ, χʷ, ʁʷ | | | Edelman and Dodykhudoeva (2009:779) |
| | | SOUTHWEST IRANIAN | | | |
| Persian | k, g, x, ɣ | | | h, ʔ | Windfuhr (1979:129) |
| Tajik | k, g, ɣ | q, χ | | h, ʔ | Khojayori and Thompson (2009:3-5) |

Table 2.14: Inventory of velar and post-velar phonemes in the Iranian languages

### 2.2.6 Taiwan

The island of Taiwan is considered to be the location from which the Austronesian language family first dispersed (Ross 2009, 2012), although the original homeland of the Austronesian languages has been placed in southern mainland China by some, namely Blust (1999b). The subgrouping of the Formosan languages is the subject of debate, and this study follows the classification argued for in Ross (2009:295, 316), which posits a "primary four-way split into Puyuma, Tsou, Rukai and Proto Nuclear Austronesian (PNAn)." This classification shows that the relationships between the Austronesian languages spoken in Taiwan are quite distant. It should also be noted that all Austronesian languages spoken outside Taiwan can be classified under a single subgrouping, Malayo-Polynesian.

A striking phonological difference between the Formosan languages and the other Austronesian languages is the presence of non-glottal post-velar consonants including both uvulars and pharyngeals. The pharyngeals of one of these languages, Amis, were investigated laryngoscopically in Edmondson et al. (2005).

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| | | PUYUMA | | | |
| Puyuma | k, g, ŋ | | | ʔ | Teng (2008) |
| | | RUKAI | | | |
| Rukai | k, (g)[31], ŋ | | | ʔ, h | Zeitoun (2007:17) |
| | | TSOU | | | |

[31] This is only "found in a few loan words" (Zeitoun 2007:16).

| | | | | | |
|---|---|---|---|---|---|
| Tsou | k, x, ŋ | | | ʔ | Tsuchida (1976:85-86) |
| | | NUCLEAR AUSTRONESIAN | | | |
| | | *Kanakanavu and Saaroa* | | | |
| Kanakanavu | k, ŋ | | | ʔ, h | Tsuchida (1976:27) |
| Saaroa | k,ŋ, (g)[32] | | | ʔ, (h)[33] | Tsuchida (1976:59) |
| | | *Northwest Formosan* | | | |
| Saisiyat | k, ŋ, w | | | ʔ, h | Zeitoun and Wu (2005:31) |
| Kulon-Pazih | k, g, ŋ, x, w | | | h | Blust (1999a:325) |
| | | *Atayalic* | | | |
| Atayal | k, ɣ, ŋ, x | q | ħ | ʔ | Rau (1992:18) |
| Seediq | k, g, ŋ, x, w | | | ʔ, h | Holmer (1996:23) |
| | | *Western Plains* | | | |
| Thao | k, (ŋ)[34], w | q | | ʔ, h | Lu (2007:13) |
| Taokas | | — — | | | |
| Favorlang-Babuza | | — — | | | |
| Papora | | — — | | | |
| Hoanya | | — — | | | |
| | | *Bunun* | | | |
| Bunun | k, (g)[35], ŋ | q | | ʔ, h | de Busser (2009:114) |
| | | *Paiwan* | | | |
| Central Paiwan | k, g, ŋ | q | | ʔ, h | Chen (2006:45) |
| | | *East Formosan* | | | |
| Basay-Trobiawan | | — — | | | |
| Kavalan | k, ŋ | q, ʁ | | ʔ, (h)[36] | Li and Tsuchida (2006:2) |

[32]This is found only in loan words (Tsuchida 1976:59).

[33]This is found only in loan words (Tsuchida 1976:59).

[34]"The velar nasal seems to be phonemic only in names, onomatopoeic words, and loans (Blust 2003:18)" (ibid.).

[35]The phoneme /g/ "only occur[s] in a small number of loan words, mainly from Isbukun Bunun and Japanese" (de Busser 2009:113).

[36]This "appears only in a few loan words" (Li and Tsuchida 2006:2).

| | | | | | |
|---|---|---|---|---|---|
| Amis | k, ŋ, x, w | | ħ | ʔ [ʔ, ʡ] | Edmondson and Tung-Chiou (2004:264) |
| Siraya | k, g, x, ŋ | | | h | Adelaar (1997:370) |

Table 2.15: Inventory of velar and post-velar phonemes in the Non-Malayo-Polynesian languages of the Austronesian stock spoken in Taiwan (the "Formosan" languages)

### 2.2.7 Southwestern Siberia

A loose geographic cluster of languages with uvular consonants also exists in a region identified here as Southwestern Siberia. It encompasses a large region in Russia roughly north of Novosibirsk near the west bank of the Yenisei river as well as southeast of Novosibirsk to Lake Baikal and south to the border with Mongolia. This is the area of the map in Vajda (2009:429) that covers the southernmost Turkic languages, Ket, and Selkup. The stocks involved in this cluster are Uralic (only Selkup), Yeniseian, and Turkic (only South Siberian languages), and they are presented roughly from north to south according to the map in Vajda (2009:429). While good documentation exists for the Yeniseian languages Ket and Kott, the documentation on the other languages is more sparse. For Assan, the uvular consonants are proposed to have existed, but the documentation on the language is so old and sparse that their existence cannot be verified.

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Selkup | k, ŋ | q | | | Helimski (1998:551) |

Table 2.16: Inventory of velar and post-velar phonemes in Selkup (Uralic stock; Samoyedic)

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Ket | k, ŋ | q | | h | Georg (2007:69) |
| Yugh† | k, g, ŋ | q, χ, ʁ | | ʔ | Verner (1990:47) |
| Kott† | k, g, x, ŋ | q, ɢ, χ, ʁ | | ʔ, h | Verner (1990:80) |
| Assan† | k, g, x | *q, *χ | | ʔ, h | Verner (1990:106) |
| Arin† | k, k', g, ŋ | q, q', χ | | (h) | Verner (1990:154) |
| Pumpokol† | k, g, ŋ | q, χ | | h | Verner (1990:125) |

Table 2.17: Inventory of velar and post-velar phonemes in the languages of the Yeniseian stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| | | NORTHEASTERN TURKIC *South Siberian* | | | |
| Altai (Southern) | $k^j$, k, g, ɣ, ŋ | [q] | | | Baskakov (1966a:508), Schönig (1998) |
| Chulym | k, g, x, ɣ, ŋ | q, χ, ʁ | | ʔ | Dul'zon (1966:449) |
| Khakas | k, g, ŋ | [χ], [ʁ] | | | Karpov (1966:430), Schönig (1998) |
| Shor | k, g | [q], [ɢ], χ | | | Babuškin and Donidze (1966:468-469) |
| Tofa (Karagas) | k, $k^h$, [g], [ɣ], ŋ | q, $q^h$, [ɢ], [ʁ], [ɴ] | | h [h, h̃, $\tilde{h}^j$][37] | (Rassadin 1971:44, 49-51) |
| Tuva | k, g, x, ŋ | [q] | | | Harrison (2000:12) |

Table 2.18: Inventory of velar and post-velar phonemes in the Turkic languages spoken in Central Siberia

### 2.2.8 The Pacific North Coast of Asia

The Pacific North Coast of Asia ranges from the Bering Strait southward down the mainland coast to the southern border of Khabarovsk Krai and includes the Kamchatka Peninsula. The Pacific North Coast of Asia may be considered a geographic cluster of languages with post-velar consonants, with the significant exception of Even (Tungusic), which still has at least phonetic [q] as an allophone of /k/ Malchukov (1995:6). The stocks in this cluster, presented approximately from north to south according to the map in Vajda (2009:429), are: Eskimo-Aleut (excluding languages spoken in North America), Chukotko-Kamchatkan, Turkic, Yukaghir, Tungusic, and Nivkh.

Because of the distribution of Even, it may be justified to split this cluster into northern and southern clusters. However, the Pacific North Coast of Asia is identified as an area by Nichols

[37]The original source describes these as pharyngeal sounds, but it is unlikely based on the other languages in this subgroup that these sounds are truly pharyngeal. Moreover, the nasalization reported to occur on and after these sounds when they occur word-initially is reminiscent of rhinoglottophilia, which occurs with glottals. Finally, the variant [$\tilde{h}^j$] is treated as a distinct phoneme, but occurs only in three words, all of with have the structure /iCV(N)/. The /i/ can explain the palatalization, and it seems reasonable to suppose that the nasalization is the allophonic rhinoglottophilia reported for /h/ given that the sound follows only a single initial vowel, /i/, and the word is composed only of sonorant sounds.

(1992). Although the Tungusic languages do not possess phonemic post-velar consonants, there is a concentration of languages near Nivkh that do use them as allophones of velar consonants and many of the Tungusic languages have been claimed to have ATR or pharyngealization vowel harmony, as in the Ola dialect of Even (Novikova 1960; Aralova et al. 2011). For these reasons Tungusic is included in this geographic cluster, creating a continuous span that connects Nivkh to the Chukotko-Kamchatkan, Yukaghir, and Eskimo-Aleut languages.

The presence of pharyngeal consonants in the Chukotko-Kamchatkan stock is notable since these languages are not normally cited among those exemplifying pharyngeal consonants. However, the verification of the presence of a pharyngeal stop that contrasts with a glottal stop in Alutor by Kibrik et al. (2000) provides strong modern evidence that the languages in the stock that are described as having pharyngeals do indeed possess them.

| *Language* | Vel | Uv | Ph/E | Gl | *Sources* |
|---|---|---|---|---|---|
| Central Siberian Yupik Eskimo | k, k$^{w}$, x, x$^{w}$, ɣ, ɣ$^{w}$, ŋ, ŋ$^{w}$, ŋ̥, ŋ̥$^{w}$ | q, q$^{w}$, χ, χ$^{w}$, ʁ, ʁ$^{w}$ | | h | de Reuse (1994:18) |
| Naukan | k, x, ɣ, ŋ | q, χ, ʁ | | | Menovščikov (1975:22-23) |
| Sirenik | k, x, ɣ, ŋ | q, χ, ʁ | | ʔ | Menovščikov (1964:16-17) |

Table 2.19: Inventory of velar and post-velar phonemes in the languages of the Eskimoan branch of the Eskimo-Aleut stock spoken in Asia

| *Language* | Vel | Uv | Ph/E | Gl | *Sources* |
|---|---|---|---|---|---|
| Itelmen | k, k’, x, ɣ, ŋ | q, q’, χ | | ʔ | Volodin (1976); Bobaljik (2006) |
| Chukchi | k, ɣ, ŋ | q | | ʔ | Skorik (1961); Spencer (1999) |
| Koryak | k, ɣ, ŋ | q | ʕ | | Žukova (1972) |
| Kerek | k, (ɣ), ŋ | q | ʕ | ʔ | Skorik (1968) |
| Alutor | k, ɣ, ŋ | q | ʡ | ʔ | Kibrik et al. (2000) |

Table 2.20: Inventory of velar and post-velar phonemes in the languages of the Chukotko-Kamchatkan stock

| *Language* | Vel | Uv | Ph/E | Gl | *Sources* |
|---|---|---|---|---|---|
| Northeastern Turkic | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| | | *North Siberian* | | | |
| Sakha (Yakut) | k, g, ŋ | [χ, ʁ] | | h | Stachowski and Menz (1998:417-418), Ubrjatova (1966:405-406) |
| Dolgan | k, g, ŋ | [q, ʁ] | | h | Artem'ev (2001:52-53) |

Table 2.21: Inventory of velar and post-velar phonemes in the Turkic languages of Northeastern Siberia

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Kolyma Yukaghir | k, g, ŋ | q, ʁ | | ʔ | Maslova (2003a) |
| Tundra Yukaghir | k, g, ŋ | q, ʁ | | | Maslova (2003b:3) |

Table 2.22: Inventory of velar and post-velar phonemes in the languages of the Yukaghir stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| | | NORTHERN TUNGUSIC | | | |
| | | *Northeastern Tungusic* | | | |
| Even | k, g, (ɣ), ŋ | [q] | | [h] | Malchukov (1995:6) |
| | | *Northwestern Tungusic* | | | |
| Evenki | k, g, x, ŋ | | | | Nedjalkov (1997:309) |
| Negidal | k, g, x, (ɣ), ŋ | [q, χ] | | | Cincius (1982:13) |
| Orok | k, g, x, (ɣ), ŋ | | | | Petrova (1967) |
| | | CENTRAL TUNGUSIC | | | |
| | | *Central-Eastern Tungusic* | | | |
| Udihe | k, g, x, ŋ | | | | Nikolaeva and Tolskaya (2001) |
| Oroch | k, kː, g, gː, x, ɣ, ŋ, ŋː | [q, qː, ɢ, ɢː, ɴ, ɴː] | | | Avrorin and Boldyrev (2001:24,30-31) |
| | | *Central-Western Tungusic* | | | |

| | | | | | |
|---|---|---|---|---|---|
| Nanai | k, g, x, ŋ | [q, ɢ, χ] | | | Avrorin (1959:19,37) |
| Ulcha | k, g, x, (ɣ), ŋ | [k, χ] | | | Sunik (1985:28-29) |
| | | SOUTHERN TUNGUSIC | | | |
| Manchu | k, g, x, ŋ | [q, ɢ, χ] | | | Gorelova (2002:85-86) |

Table 2.23: Inventory of velar and post-velar phonemes in the languages of the Tungusic stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Nivkh | k, $k^h$, g, x, ɣ, ŋ | q, $q^h$, ɢ, χ, ʁ | | h | Gruzdeva (1998) |

Table 2.24: Inventory of velar and post-velar phonemes in Nivkh (Gilyak; isolate)

### 2.2.9 The Pacific Northwest Coast of North America

The following tables show the inventories of languages in the Pacific Northwest Coast geographic cluster. The cluster is defined here as including the languages of the Athabascan, Wakashan, Salish, Chimakuan, and Sahaptin stocks. The cluster ranges from the coastal Oregon-Washington border at the Columbia River in the south to the southernmost border of Alaska along the coast thence to the Yukon in the north. On the southern end, the cluster extends inland toward Idaho and Kalispell, MT to cover the territory of the Interior Salish and Sahaptin languages. Ultimately, the cluster may be thought of as extending all the way to Northern Alaska, connecting with the North Pacific Coast of Asia cluster geographically and linguistically via the Eskimo-Aleut stock.[38]

In the inventories below, the Athabaskan languages are listed according to the classification given in Campbell (1997:111). Many Athabaskan languages contain uvular consonants (Krauss and Golla 1981:72), and uvulars are reconstructed for Proto-Athabaskan (Cook 1981:255,264). The Wakashan languages are listed in alphabetical order, while the Salish languages are listed by subgroups roughly from north to south along the coast and then to the interior as in Czaykowska-Higgins and Kinkade (1998:3). The uvular ejectives are marked as marginal for Ditidaht and Nuu-chah-nulth due to their rarity. Most occurrences of these phonemes became the pharyngeal/epiglottal consonant /ʔ/ Jacobsen (1969). In the Salish languages, the labialized velar (round velar, labio-velar) consonants are always present, but the plain velars are either missing, marginal, or noticeably palatalized. Czaykowska-Higgins and Kinkade (1998:8) note the existence of “a correlation between the presence of a palato-alveolar series of obstruents and the absence of a [plain] velar series, and vice versa.”

[38]This would require the addition of the inventories of Eyak, Tlingit, Haida, and the Alaskan Eskimo-Aleut languages.

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| | | NORTHERN ATHABASKAN | | | |
| Ahtna | (realized as palatal) | q, qʰ, q', χ, ʁ, ɴ | | ʔ, h | Tuttle (2010:344) |
| Tanaina | k, kʰ, k', x, ɣ, ŋ | q, qʰ, q', χ, ʁ | | ʔ, h | Kari (2007:xxiv) |
| Ingalik | g, k, k', ŋ | ɢ, q, q', χ, ɣ | | ʔ, h | Hargus (1991:1) |
| Holikachuk | | —— | | | |
| Koyukon | k, kʰ, k', x, ɣ | q, qʰ q', χ, ʁ | | ʔ, h | Jetté and Jones (2000) |
| Kolchan | k, kʰ, k', x, ɣ | | | ʔ | Collins and Petruska (1979:iii-vi) |
| Lower Tanana | | —— | | | |
| Tanacross | k, kʰ, k', x, ɣ | | | | Holton (2000:24) |
| Upper Tanana | | —— | | | |
| Han | | —— | | | |
| Kutchin | | —— | | | |
| Tuchone | | —— | | | |
| Tsetsaut | | —— | | | |
| Tahltan | k, kʷ, k', kʷ', g, gʷ, x, xʷ, ɣ, w | q, q', ɢ, χ, ʁ | | ʔ, h | Nater (1989:27) |
| Sekani | k, kʰ, k', x, ɣ, kʷ, kʷʰ, k'ʷ, w, ʍ | | | ʔ, h | Hargus (1988:8) |
| Beaver | k, kʰ, k', x, ɣ, w | | | ʔ, h | Randoja (1990:20) |
| Chipewyan | g, k, k', x, ɣ, gʷ, kʷ, kʷ', xʷ, w | | | ʔ, h | Cook (2006:238) |
| Slave-Hare (Slavey Proper) | k, kʰ, k', x, ɣ | | | ʔ, h | Rice (1989:30) |
| Slave-Hare (Mountain) | k, kʰ, k', x, ɣ | | | ʔ, h | Rice (1989:30) |
| Slave-Hare (Bearlake) | k, kʰ k', x, ɣ, kʷ, kʰʷ, k'ʷ, w, wh | | | ʔ, h | Rice (1989:29) |

| | | | | |
|---|---|---|---|---|
| Slave-Hare (Hare) | $k^{w}$, $k^{h}$, k’, x, ɣ, w’, w | | ʔ, h | Rice (1989:29) |
| Dogrib | k͡x, $k^{w}$, k’, g, x, ɣ, $ɣ^{w}$ | | ʔ, h | McDonough (2013) |
| Babine | $k^{w}$, $k^{wh}$, $x^{w}$, w | q, $q^{h}$, q’, χ, ʁ | ʔ, h | Wright et al. (2002:45) |
| Carrier | $k^{h}$, k, k’, x, ɣ, $k^{w}$, $k^{hw}$, $k’^{w}$, w, $x^{w}$, ŋ, | | ʔ, h | Story (1984:8) |
| Chilcotin | k, $k^{w}$, k’, $k^{w}$’, g, $g^{w}$, $x^{w}$, w | q, $q^{w}$, q’, $q^{w}$’, ɢ, $ɢ^{w}$, χ, $χ^{w}$, ʁ, $ʁ^{w}$ | ʔ, h | Hansson (2007:96) |
| Nicola | | — — | | |
| Sarcee | g, k, k’, x, ɣ, $g^{w}$, $k^{w}$, $k^{w}$’ | | | Cook (1984:7) |
| | | KWALHIOQUA-TLATSKANAI | | |
| Kwalhioqua-Tlatskanai | | — — | | |
| | | PACIFIC COAST ATHABASKAN | | |
| | | *Oregon Athabaskan* | | |
| Upper Umpqua | | — — | | |
| Tolowa-Chetco | k, $k^{h}$ k’, x, ɣ, $k^{w}$, $k^{hw}$, $k’^{w}$ | | ʔ, h | Bright (1964:102) |
| Tututni-Chasta Costa-Coquille | k, k’, x, ɣ, $k^{w}$, $k^{w}$, $x^{w}$, $ɣ^{w}$ | | ʔ, h | Golla (1976:218) |
| Applegate-Galice | k, $k^{h}$ k’, $k^{w}$, $k^{hw}$, $k’^{w}$, w | | ʔ, h | Hoijer (1966:320) |
| | | *California Athabaskan* | | |
| Hupa | $k^{j}$, $k^{jh}$, $k^{j}$’, x, $x^{w}$, $^{ʔ}w$, w, ʍ | q, q’ | | Gordon (2001:4) |
| Mattole (Bear River) | | — — | | |
| Wailaki-Sinkyone(-Nongatl-Lassik) | k, $k^{h}$, k’, g | | | Goddard (1923:77) |
| Kato | k, $k^{h}$ k’, g | | | Goddard (1909, 1912:13, 6) |
| | | APACHEAN | | |

| | | | | | |
|---|---|---|---|---|---|
| Navajo | k$^{h}$, k, k', k, k$^{wh}$, k$^{w}$, x, ɣ, ɰ | | | ʔ, h | McDonough (2003:4) |
| | | *Apache* | | | |
| Jicarilla Apache | k, k$^{h}$ k', k$^{wh}$, k$^{w}$, x, ɣ | | | ʔ | Tuttle and Sandoval (2002:196) |
| Lipan | | —— | | | |
| Kiowa Apache | | —— | | | |
| Western Apache | k, k$^{h}$ k', x, ɣ | | | ʔ, h | Gordon et al. (2001:418) |
| Chiricahua | k, k$^{h}$ k', x, ɣ | | | ʔ, h | Hoijer (1946) |
| Mescalero | k, k$^{h}$ k', x, ɣ | | | ʔ, h | Hoijer (1946) |

Table 2.25: Inventory of velar and post-velar phonemes in the languages of the Athabaskan stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Ditidaht | k, k$^{w}$, k', k'$^{w}$, x, x$^{w}$, w, $^{ʔ}$w | q, q$^{w}$, (q'), (q'$^{w}$), χ, χ$^{w}$ | ʡ, (ħ) | ʔ, h | Werle (2007:75) |
| Haisla | k, k$^{w}$, k', k'$^{w}$, g, g$^{w}$, x, x$^{w}$, w, $^{ʔ}$w | q, q$^{w}$, q', q'$^{w}$, ɢ, ɢ$^{w}$, χ, χ$^{w}$ | | ʔ, h | Vink (1977:112) |
| Heiltsuk | k, k$^{w}$, k', k'$^{w}$, g, g$^{w}$, x, x$^{w}$, w, $^{ʔ}$w | q, q$^{w}$, q', q'$^{w}$, ɢ, ɢ$^{w}$, χ, χ$^{w}$ | | ʔ, h | Rath (1981:6) |
| Kwak'wala | k, k$^{w}$, k', k'$^{w}$, g, g$^{w}$, x, x$^{w}$, w, $^{ʔ}$w | q, q$^{w}$, q', q'$^{w}$, ɢ, ɢ$^{w}$, χ, χ$^{w}$ | | ʔ, h | Grubb (1977:6) |
| Makah | k, k$^{w}$, k', k'$^{w}$, x, x$^{w}$, w | q, q$^{w}$, q', q'$^{w}$, χ, χ$^{w}$ | | ʔ, h | Davidson (2002:75) |
| Nuu-chah-nulth | k, k$^{w}$, k', k'$^{w}$, x, x$^{w}$ | q, q$^{w}$, (q'), (q'$^{w}$), (χ), (χ$^{w}$), w, $^{ʔ}$w | ʡ, ħ | ʔ, h | Davidson (2002:10) |
| Oowekyala | k, k$^{w}$, k', k'$^{w}$, g, g$^{w}$, x, x$^{w}$, w, $^{ʔ}$w | q, q$^{w}$, q', q'$^{w}$, ɢ, ɢ$^{w}$, χ, χ$^{w}$ | | ʔ, h | Howe (2000:21) |

Table 2.26: Inventory of velar and post-velar phonemes in the languages of the Wakashan stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| | | *I - Bella Coola* | | | |
| Bella Coola | k, $k^w$, k', $k'^w$, x, $x^w$, w | q, $q^w$, q', $q'^w$, χ, $χ^w$ | | ʔ, (h) | Bagemihl (1991:591) |
| | | *II - Central Salish* | | | |
| Comox | k, $k^w$, k', $k'^w$, $x^w$, g, w, $^ʔw$ | q, $q^w$, q', $q'^w$, χ, $χ^w$ | | ʔ, h | Davis (1970:2), Kennedy and Bouchard (1990:441) |
| Sechelt | (k), $k^w$, (k'), $k'^w$, (x), $x^w$, w, $^ʔw$ | q, $q^w$, q', $q'^w$, χ, $χ^w$ | | ʔ, h | Timmers (1974:10), Kennedy and Bouchard (1990:441)[39] |
| Squamish | k, $k^w$, k', $k'^w$, $x^w$, w | q, $q^w$, q', $q'^w$, χ, $χ^w$ | | ʔ, (h) | Tamburri Watt et al. (2000:217), Kuipers (1967:21-23) |
| Halkomelem | (k), $k^w$, (k'), $k'^w$, $x^j$, $x^w$ | q, $q^w$, q', $q'^w$, χ, $χ^w$ | | ʔ, h | Galloway (1993:16-25) |
| Northern Straits | (k), $k^w$, $k'^w$, $x^w$ | q, $q^w$, q', $q'^w$, χ, $χ^w$ | | ʔ, h | Thompson et al. (1974:183) |
| Klallam | (k), $k^w$, $k'^w$, $x^w$, w, $^ʔw$ | q, $q^w$, q', $q'^w$, χ, $χ^w$, ɴ, $^ʔ$ɴ | | ʔ, h | Montler (1998:366) |
| Nooksack | (k), $k^w$, $k'^w$, $x^w$, w | q, $q^w$, q', $q'^w$, χ, $χ^w$ | | ʔ, h | Galloway (1983:86) |
| Lushootseed | k, $k^w$, k', $k'^w$, g, $g^w$, $x^w$, w, $^ʔw$ | q, $q^w$, q', $q'^w$, χ, $χ^w$ | | ʔ, h | Beck (1996:38), Suttles and Lane (1990:485) |
| Twana | k, $k^w$, k', $k'^w$, $x^w$, w, $^ʔw$ | q, $q^w$, q', $q'^w$, χ, $χ^w$ | | ʔ, h | Suttles and Lane (1990:485) |
| | | *III - Tsamosan* | | | |
| Quinault | k, $k^w$, k', $k'^w$, g, x, $x^w$, w, $^ʔw$ | q, $q^w$, q', $q'^w$, χ, $χ^w$ | | ʔ, h | Hajda (1990:503) |
| Lower Chehalis | k, $k^w$, k', $k'^w$, $x^w$, w, $^ʔw$ | q, $q^w$, q', $q'^w$, χ, $χ^w$ | | ʔ, h | Hajda (1990:503) |
| Upper Chehalis | k, $k^w$, k', $k'^w$, $x^w$, w, $^ʔw$ | q, $q^w$, q', $q'^w$, χ, $χ^w$ | | ʔ, h | Kinkade (1963:182) |

[39] Pentlatch, omitted in this table, "had a similar phoneme inventory" to Sechelt (Kennedy and Bouchard 1990:441).

| | | | | | |
|---|---|---|---|---|---|
| Cowlitz | k, $k^w$, k’, $k’^w$, x, $x^w$, w, $^ʔw$ | q, $q^w$, q’, $q’^w$, χ, $χ^w$ | | ʔ, h | Kinkade (2004:xix-xxi) |
| Tillamook | k, $k^w$, k’, $k’^w$, g, $g^w$, x, $x^w$, w | q, $q^w$, q’, $q’^w$, ɢ, $ɢ^w$, χ, $χ^w$ | | ʔ, h | Thompson and Thompson (1966:314), Thompson and Thompson (1985:144) |
| | | *IV - Interior Salish* | | | |
| Lillooet | k, $k^w$, k’, $k’^w$, x, $x^w$, ɣ, $ɣ^w$, w, $^ʔw$ | q, $q^w$, q’, $q’^w$, χ, $χ^w$ | $ʕ^ʔ$, $ʕ^{ʔw}$, ʕ, $ʕ^w$ | ʔ, h | van Eijk (1997:2), Czaykowska-Higgins and Kinkade (1998:7-9) |
| Thompson | k, $k^w$, k’, $k’^w$, x, $x^w$, (ɣ), ($ɣ^ʔ$), w, $^ʔw$ | q, $q^w$, q’, $q’^w$, χ, $χ^w$ | $ʕ^ʔ$[ʡ], $ʕ^{ʔw}$[$ʡ^w$], ʕ [ʕ, $ʁ^ʕ$, $ʀ^ʕ$], $ʕ^w$ [$ʕ^w$, $ʁ^{ʕw}$, $ʀ^{ʕw}$] | ʔ, h | Carlson et al. (2004:260), Thompson and Thompson (1992) |
| Shuswap | k, $k^w$, k’, $k’^w$, x, $x^w$, ɣ, $ɣ^w$, w, $^ʔw$ | q, $q^w$, q’, $q’^w$, χ, $χ^w$ | $ʕ^ʔ$, $ʕ^{ʔw}$, ʕ, $ʕ^w$ | ʔ, h | Czaykowska-Higgins and Kinkade (1998:7-9) |
| Colville-Okanagan | k, $k^w$, k’, $k’^w$, x, $x^w$, w, $^ʔw$ | q, $q^w$, q’, $q’^w$, χ, $χ^w$ | $ʕ^ʔ$, $ʕ^{ʔw}$, ʕ, $ʕ^w$ | ʔ, h | Mattina (1973:7), Czaykowska-Higgins and Kinkade (1998:7-9) |
| Moses-Columbia | k, $k^w$, k’, $k’^w$, x, $x^w$, ɣ, $ɣ^w$, w, $^ʔw$ | q, $q^w$, q’, $q’^w$, χ, $χ^w$ | $ʕ^ʔ$, $ʕ^{ʔw}$, ħ, $ħ^w$, ʕ, $ʕ^w$ | ʔ, h | Bessell (1998a), Czaykowska-Higgins (2004:90-91) |
| Spokane-Kalispel-Flathead | (k), $k^w$, $k’^w$, $x^w$, w, $^ʔw$ | q, $q^w$, q’, $q’^w$, χ, $χ^w$ | $ʕ^ʔ$, $ʕ^{ʔw}$, ʕ, $ʕ^w$ | ʔ, h | Flemming et al. (2008:469) |
| Coeur d’Alene | $k^w$, $k’^w$, $g^w$, $x^w$, w, $^ʔw$ | q, $q^w$, q’, $q’^w$, χ, $χ^w$ | $ʕ^ʔ$, $ʕ^{ʔw}$, ʕ, $ʕ^w$ | ʔ, h | Doak (1997:7), Czaykowska-Higgins and Kinkade (1998:7-9) |

Table 2.27: Inventory of velar and post-velar phonemes in the languages of the Salish stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Chemakum | $k^{w}$, $k'^{w}$, $x^{w}$, w | q, $q^{w}$, q', $q'^{w}$, $\chi$, $\chi^{w}$ | | ʔ, h | Elmendorf (1990:438) |
| Quileute | k, $k^{w}$, k', $k'^{w}$, x, $x^{w}$, w | q, $q^{w}$, q', $q'^{w}$, $\chi$, $\chi^{w}$ | | ʔ, h | Andrade (1933) |

Table 2.28: Inventory of velar and post-velar phonemes in the languages of the Chimakuan stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Nez Perce | k, k', x | q, q', $\chi$ | | ʔ, h | Aoki (1965:1) |
| Sahaptin | k, $k^{w}$, k', $k'^{w}$, x, $x^{w}$, w | q, $q^{w}$, q', $q'^{w}$, $\chi$, $\chi^{w}$ | | ʔ, h | Hargus and Beavert (2002:318) |

Table 2.29: Inventory of velar and post-velar phonemes in the languages of the Sahaptin stock

### 2.2.10 The Andes

The Andes are defined here not just as the Altiplano, but as the continuous chain of mountains from Venezuela to the southernmost tip of Tierra del Fuego. This cluster does not cover the entire Andes, but ranges from the area around Chiclayo, Peru, where the Quechua IIA languages are spoken, all the way south to the very end of the continent. It includes languages from the Quechua, Uru-Chipaya, Jaqi (Aymaran), Alacalufan, and Chon stocks as well as the isolate Kunza and the mixed, secret language Callawaya.

The inventories for these languages and their genetic affiliations follow those shown in the South American Phonological Inventory Database (SAPhon; Michael et al. 2013). The linguistic stocks and their member languages are presented approximately from north to south down the Andes mountain range toward Tierra del Fuego. The only exception is Chon, which is north and east of Alacalufan's southernmost language. Its languages are listed from south to north as if one were starting in Tierra del Fuego and heading north. While the names for the Quechua languages follow the names in SAPhon, their subclassification follows that embodied in Map 5 of Adelaar and Muysken (2004:184), dividing the stock into Quechua I, IIA, IIB, and IIC. The ordering of the Quechua subgroups and the languages in them is approximately north to south. Unless otherwise noted, the source for the inventory of each language is the SAPhon database and the primary references cited therein.

| *Language* | VEL | UV | PH/E | GL |
|---|---|---|---|---|
| | QUECHUA IIB | | | |
| Inga (Highland dialect) | k, g, x | | | |
| Inga (Jungle dialect) | k, x | | | |
| Imbabura Quichua | k, x | | | |
| Tena Quechua | k, g, x | | | |
| Napo Quichua | k, g | | | h |
| Salasaca Quichua | k, $k^h$, g, x | | | |
| Chachapoyas Quechua | k | | | |
| San Martín Quechua | k, x | | | |
| | QUECHUA IIA | | | |
| Ferreñafe Quechua | k | q | | |
| Cajamarca Quechua | k, x | q | | |
| | QUECHUA I | | | |
| Ancash Quechua (Sihuas and Corongo dialects) | k | q | | h |
| Huaylas-Conchucos Quechua | k | q | | h |
| Huallaga (Huánuco) Quechua | k | q | | h |
| Yaru Quechua | k, g, x, ŋ | χ | | |
| North Junín Quechua (San Pedro de Cajas dialect) | k, g, x, ŋ | χ | | |
| North Junín Quechua (Tarma dialect) | k, g, x, ŋ | | | |
| Jauja-Huanca Quechua | k | | | h |
| | QUECHUA IIC | | | |
| Ayacucho Quechua | k | q | | h |
| Cuzco-Collao Quechua | k, $k^h$, k’ | q, $q^h$, q’ | | h |
| Bolivian Quechua (Northern and Southern dialects) | k, $k^h$, k’ | q, $q^h$, q’ | | h |
| Santiago del Estero Quechua | k, g, x | q, ɢ, χ | | |

Table 2.30: Inventory of velar and post-velar phonemes in the languages of the Quechua stock

| *Language* | VEL | UV | PH/E | GL |
|---|---|---|---|---|
| Uru | k, $k^w$, k’, x | q, q’ | | |
| Chipaya | k, $k^w$, $k^h$, k’, x, $x^w$, ŋ | q, $q^w$, $q^h$, q’, χ, $χ^w$ | | |

Table 2.31: Inventory of velar and post-velar phonemes in the languages of the Uru-Chipaya stock

| *Language* | VEL | UV | PH/E | GL |
|---|---|---|---|---|
| Callawaya | k, $k^h$, k’, x | q, $q^h$, q’ | | |

Table 2.32: Inventory of velar and post-velar phonemes in Callawaya (mixed, perhaps Quechua and Puquina)

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Jaqaru | k, $k^h$, k’, x, ŋ | q, $q^h$, q’ | | | Hardman (1983, 2000) |
| Aymara (Central dialect) | k, $k^h$, k’, x | q, $q^h$, q’, χ | | | |
| Aymara (Chilean dialect) | k, $k^h$, k’, ŋ | q, $q^h$, q’ | | h | |

Table 2.33: Inventory of velar and post-velar phonemes in the languages of the Jaqi (Aymaran) stock

| *Language* | VEL | UV | PH/E | GL |
|---|---|---|---|---|
| Kunza | k, k’, x, ɣ | q, q’, χ | | ʔ, h |

Table 2.34: Inventory of velar and post-velar phonemes in Kunza (isolate)

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Kawesqar | k, k’ | q | | h | Aguilera (2001:19-26) |
| Alacalufe (Central) | k, k’ | q | | h | |
| Alacalufe (Southern) | k, k’ | q | | h | |

Table 2.35: Inventory of velar and post-velar phonemes in the languages of the Alacalufan stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Haush | k, k’, x | | | h | |
| Ona | k, k’, x | q, q’ | | ʔ, h | |
| Teushen | k, k’, g, x | | | ʔ | |
| Tehuelche | k, k’, g, x | q, q’, ɢ, χ | | ʔ | Garay (1998) |
| Günün Yajich | k, k’, g, x | q | | ʔ | |

Table 2.36: Inventory of velar and post-velar phonemes in the languages of the Chon stock (from south to north)

### 2.2.11 The Gran Chaco

In this work, the Chacoan cluster of languages is defined as a geographic area occupying territory in both Argentina and Paraguay. The cluster includes the Guaicuru and Mataco stocks, as well as the isolate Vilela. The Chacoan cluster has been identified as a culture area, but it has not yet been determined whether it is also a Sprachbund (Campbell and Grondona 2012:625). This survey does not settle that question, but the prevalence of uvular consonants in unrelated stocks makes the their presence a possible areal feature. The territory identified as a cluster in this survey can be thought of as surrounding a line running from Reconquista, Argentina, to the southwestern border of Paraguay (approximately at Resistencia, Argentina) and along the Paraguay-Argentina border to Bolivia. The cluster centers around the territory of the Guaicuru language Pilagá.

This language, Pilagá, is of particular interest because it is the only language in South America that possesses a pharyngeal consonant, the voiced fricative /ʕ/. The development of a pharyngeal consonant in this language has ramifications for understanding how and where pharyngeal/epiglottal consonants arise. Both Pilagá and the Wakashan languages Nuuchahnulth and Ditidaht are languages with endogenous uvular consonants in geographic clusters where uvular consonants are widespread. This suggests that when uvulars are an unmarked feature not only of the stock, but of a geographic cluster of languages from different stocks, then the uvular consonants are able to accrue and retain an additional phonetic elaboration to become pharyngeal.[40]

It is worth noting that the Guaicuru language Kadiwéu is a geographic outlier and is spoken in the extreme central western part of the Brazilian state of Mato Grosso do Sul near the border with Paraguay. In addition, the genetic relationships of the stocks composing the Chacoan cluster are not completely certain. Viegas Barros (1993) proposes a relationship between the Mataco and Guaicuru languages. He also proposes a relationship between Lule and Vilela (Viegas Barros 2008), which are treated here as isolates. Genetic and areal connections to languages and stocks outside the Chacoan cluster are a possibility as well, but it is far from clear where such connections may exist.

[40]For possible articulatory explanations of the genesis of these pharyngeals (in Wakashan), see Carlson and Esling (2003) and Moisik (2013:453-469).

The languages of the Chacoan cluster are presented in the tables below in the geographic order of south to north along the line defined for the cluster. The names of the languages, their identification as members of a particular stock, and their phonemic inventories are from SAPhon (Michael et al. 2013) unless otherwise noted.

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Abipon | k, ɣ | q, ʁ | | h | |
| Mocoví | k, ɣ | q, ʁ | | ʔ, h | |
| Toba (Lañagashik dialect) | k, g | | | ʔ, h | |
| Toba (Takshek dialect) | k, g | q, ʁ | | ʔ, h | |
| Pilagá | k, g | q | ʕ | ʔ, h | |
| Kadiwéu | k, g, gː | q, ɢ | | | |

Table 2.37: Inventory of velar and post-velar phonemes in the languages of the Guaicuru stock

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Vilela | k, k', g | q, q', ɢ | | ʔ, h | |

Table 2.38: Inventory of velar and post-velar phonemes in Vilela (isolate)

| *Language* | VEL | UV | PH/E | GL | *Sources* |
|---|---|---|---|---|---|
| Maka | k, k', x | q, q', χ | | ʔ, h | |
| Chulupí | k, k', x, k͡l | | | ʔ | |
| Wichí (Misión la Paz dialect) | k, $k^w$, k', x, $x^w$ | q, $q^w$ | | h | |
| Chorote (Iyo'wujwa and Iyowa'ja dialects) | k, k', x | | | ʔ | |

Table 2.39: Inventory of velar and post-velar phonemes in the languages of the Mataco stock

### 2.2.12 Other Languages or Stocks Known to Contain Post-Velar Consonants

This survey has identified geographic clusters that are rich in languages with post-velar consonants, specifically uvulars and pharyngeals/epiglottals. However, there are other languages that contain post-velar consonants that, although they are not surveyed in detail here, deserve mention to provide a more complete picture of the distribution of (non-glottal) post-velar consonants.

In North America, almost all the languages along the coast of the Pacific Northwest possess post-velar consonants, especially uvulars. As shown, all the Salish and Wakashan languages contain uvulars and some from each family also contain pharyngeals, particularly in the Interior Salish and Southern Wakashan subgroups. Haida is also reported to possess pharyngeals, at least in the northern dialects.[41] These came from the uvular consonants /ɢ/ and /χ/, but not /q/ and /q'/ (Mithun 1999:18, citing Krauss 1979), which contrasts with the Wakashan development of */q'/ > /ʕ/ (Jacobsen 1969). Achumawi (Palainihan; Nevin 1998), spoken in northeastern California, is the only language in North America outside of the Pacific Northwest Coast cluster to contain a pharyngeal/epiglottal consonant, /ʜ/ (Nevin 1998:53). Uvulars also occur in Tlingit, Eyak, and various languages in California, including Kashaya. Uvulars are reconstructed for Proto-Mayan (Campbell and Kaufman 1985:190) and occur in some modern Mayan languages, including Q'anjob'al (Shosted 2009), Mam (England 1983), and Jacaltec (Day 1973; Craig 1977). Finally, some languages in the Uto-Aztecan stock contain uvulars. Other languages with uvulars are distributed throughout Mesoamerica, as is apparent from the survey in Yasugi (1993).

In South America, languages like Japreria (Carib; Oquendo 2004) and Xiriâna (Arawak; Michael et al. 2012) contain a uvular trill as their only post-velar consonant. In addition, a number of South American Arawakan languages (Michael et al. 2013) are claimed to contain a uvular nasal.

In Asia, post-velars occur in a few languages outside of the areas surveyed. For example, uvulars occur in a Miao-Yao language, Hmong Njua, and provide the only attestation encountered in this survey of a prenasalized aspirated uvular stop /$^{\text{N}}$q$^{\text{h}}$/ (Lyman 1979). Hmong Njua also has a prenasalized voiced uvular stop /$^{\text{N}}$ɢ/ (Lyman 1979), which is extremely rare, and only attested elsewhere in ǂHõa (Honken 2013a:85). A Dravidian language, Kurukh, also contains a uvular trill, whose main realization is claimed to be voiceless (Gordon 1976:15). The isolate Kusunda, spoken in Nepal, contrasts a voiceless uvular stop /q/ with a voiced uvular stop /ɢ/ and a uvular nasal /ɴ/ (Watters 2005:377). However, the voiced stop is actually pronounced as a pharyngeal fricative, [ʕ], as is the nasal, except that it also causes nasalization on the preceding vowel. Both of these voiced consonants cause the preceding vowel to be pronounced with a lower pitch. The pharyngeals of Kusunda represent the only occurrence of a pharyngeal consonant anywhere in South Asia. Finally, it seems likely that there are additional languages in Papua New Guinea that contain uvulars given the number of languages spoken there and the paucity of documentation for many of the languages.

In Europe, the rhotic phoneme in French and German is realized as a uvular fricative, trill, or approximant. In German, it is possible for a coda rhotic (which is written by default as /ʁ/ here) to drop out and lower the F2 of a preceding vowel (Dittrich and Reibisch 2006), creating an effect similar to pharyngealization. In French, the formation of a glide from a high vowel is inhibited by /ʁ/, but not by /l/, after an obstruent and before a vowel (Graff et al. 2013).

[41] An article being prepared on Queen Charlotte Island Haida by Joyce McDonough, Jordan Lachler, and Timothy Dozat promises to enrich the phonetic description of Haida.

## 2.3 Survey Results

### 2.3.1 Counts

There were 322 total languages in the sample for which there was enough information in sources to compile a post-velar phonemic inventory.[42] Of all 322 languages sampled, 291 (90.4%) contain at least one post-velar consonant phoneme. Table 2.40 shows how many languages contained a consonant at each given post-velar place of articulation. These numbers indicate that these languages contained at least one consonant at the given place of articulation, possibly in addition to other post-velars at other places. The percentage is out of the total languages in the sample (291) that contained at least one post-velar. Phonemes that were in any way marginal and segments that occurred only phonetically were not counted in any of the counts in Tables 2.40 and 2.41.

| *Place of Articulation* | *Count* | *Percent of Lgs. with Post-Velars* |
|---|---|---|
| Uvular | 201 | 69% |
| Pharyngeal | 85 | 29% |
| Glottal | 259 | 89% |

Table 2.40: Number of languages that contained at least one consonant at the given place of articulation out of the total number of languages in the sample that contained at least one post-velar

These counts confirm that glottals are still the most common post-velar phoneme, even in a sample that mainly contains languages that were identified by the presence of supra-glottal post-velar phonemes (uvulars and pharyngeals). The glottals are followed in ubiquity by the uvulars, and finally by the pharyngeals.

Table 2.41 shows the number of languages that had post-velar phonemes at certain places of articulation while lacking others. As in the previous table, the percentage is out of the total languages in the sample (291) that contained at least one post-velar consonant phoneme.

| *Lgs. that contain:* | *But lack:* | *Count* | *Percent of Lgs. with Post-Velars* |
|---|---|---|---|
| Uvulars | Pharyngeals, Glottals | 28 | 10% |
| Pharyngeals | Uvulars, Glottals | 0 | 0% |
| Glottals | Uvulars, Pharyngeals | 62 | 21% |
| Uvulars, Pharyngeals | Glottals | 1 | 0.34% |
| Uvulars, Glottals | Pharyngeals | 106 | 36% |
| Pharyngeals, Glottals | Uvulars | 18 | 6% |
| Uvulars, Pharyngeals, Glottals | — | 66 | 23% |

[42] That is, languages whose phonemic inventory is listed as "— —" or with a note like "Very similar to *X language*" are not part of this 322 language total.

Table 2.41: Number of languages that contained phonemes at the given combinations of places of articulation out of the total number of languages in the sample that contained at least one post-velar

A significant finding from this table is that pharyngeals almost never occur without another post-velar phoneme in the language's inventory (Minyanka (Senufo) is an exception; see §2.4.1). It is also extremely rare for uvulars and pharyngeals to occur without glottals also occurring, and the only language with this type of inventory is Koryak (Chukotko-Kamchatkan). The fact that this combination does not occur, but that there are 17 languages with pharyngeals and glottals but no uvulars, could be seen as evidence for a tendency in sound change whereby pharyngeals are more likely to develop from uvulars than from glottals. Additional support for this idea is the evolution of pharyngeals from uvulars documented for Southern Wakashan (Nuuchahnulth, Ditidaht) and Pilagá as well as the way that the voiced uvular phonemes of Kusunda are "heavily pharyngealized" to the point that they are realized as pharyngeals (Watters 2005:377). In languages with post-velar consonants at multiple places of articulation, the most common combination appears to be uvulars and glottals with no pharyngeals.[43] As a whole, these distributions provide evidence that a common scenario in which pharyngeals originate historically is that they come from uvulars in languages in which both uvulars and glottals are present in the phonemic inventory.

### 2.3.2 Attested Post-Velar Consonants

The post-velar consonants attested as phonemes in the survey are summarized below, primarily in the tables. Post-velar consonants whose manner of articulation is not further specialized (e.g. by phonation, glottalization, or a secondary articulation) or which are attested extremely rarely are noted in the text below the tables. Note that only the primary realization of phonemes, not less common phonetic realizations, are listed below. The tables are organized by manner (stop, affricate, fricative) then by voicing, broadly construed (unaspirated/unmarked, aspirated, ejective, tense/long, voiced). For each table, the base phoneme is attested. Shading indicates a logically impossible articulation, and a long dash indicates that the consonant was not found.

To present all the possible consonants, the base of a phoneme had to be chosen. This means that in some cases, certain contrasts have to be chosen as primary over others. For example, in table 2.45, it is implied that for the phoneme /qː'/, the tenseness or length of the phoneme is the base to which glottalization is applied. Another interpretation is that the ejective /q'/ is realized as tense or with length. The choice between interpretations will depend on other evidence within each language, so the presentation given here should not be seen as suggesting the primacy of a certain form as a base form for all languages.

[43]Cross-linguistically, languages with glottals, but without uvulars or pharyngeals, are far more common than represented in this survey, which contains a majority of languages with uvulars and pharyngeals by design.

| / q / | *Labialized* | *Palatalized* | *pharyngealized* | *Prenasalized* |
|---|---|---|---|---|
| *Base* | $q^{w}$ | $q^{j}$ | $q^{ʕ}$ | $^{N}q$ |
| *pharyngealized* | $q^{ʕw}$ | — | | — |

Table 2.42: Voiceless unaspirated (or unmarked for aspiration) uvular stops

| / $q^{h}$ / | *Labialized* | *Palatalized* | *pharyngealized* | *Prenasalized* |
|---|---|---|---|---|
| *Base* | $q^{hw}$ | — | — | $^{N}q^{h}$ |
| *pharyngealized* | — | — | | — |

Table 2.43: Voiceless aspirated uvular stops

| / q' / | *Labialized* | *Palatalized* | *pharyngealized* | *Prenasalized* |
|---|---|---|---|---|
| *Base* | $q'^{w}$ | $q'^{j}$ | $q'^{ʕ}$ | — |
| *pharyngealized* | $q'^{ʕw}$ | — | | — |

Table 2.44: Voiceless ejective uvular stops

| / qː / | *Labialized* | *Palatalized* | *pharyngealized* | *Ejective* |
|---|---|---|---|---|
| *Base* | $qː^{w}$ | — | $qː^{ʕ}$ | qː' |
| *pharyngealized* | — | — | | — |

Table 2.45: Voiceless tense/long uvular stops

| / ɢ / | *Plain* | *Labialized* | *pharyngealized* | *Prenasalized* | *Tense/Long* |
|---|---|---|---|---|---|
| *Base* | ɢ | $ɢ^{w}$ | $ɢ^{ʕ}$ | $^{N}ɢ$ | ɢː |
| *pharyngealized* | — | $ɢ^{ʕw}$ | | — | — |
| *Aspirated* | $ɢ^{ɦ}$ | — | — | — | — |
| *Glottalized* | $ɢ^{ʔ}$ | — | — | — | — |

Table 2.46: Voiced uvular stops

| / q͡χ / | *Labialized* | *pharyngealized* | *Tense/Long* |
|---|---|---|---|
| *Base* | q͡χ$^{w}$ | — | q͡χː |
| *pharyngealized* | — | | — |

Table 2.47: Voiceless uvular affricate (unmarked for aspiration)

| / q͡χ$^{h}$ / | *Labialized* | *pharyngealized* | *Tense/Long* |
|---|---|---|---|
| *Base* | q͡χ$^{hw}$ | q͡χ$^{hʕ}$ | — |
| *pharyngealized* | — | | — |

Table 2.48: Voiceless aspirated uvular affricate

| / q͡χ' / | *Labialized* | *pharyngealized* | *Tense/Long* |
|---|---|---|---|
| *Base* | q͡χ'$^{w}$ | q͡χ'$^{ʕ}$ | q͡χː' |
| *pharyngealized* | q͡χ'$^{ʕw}$ | | — |

Table 2.49: Voiceless ejective uvular affricate

| / χ / | *Labialized* | *Palatalized* | *pharyngealized* |
|---|---|---|---|
| *Base* | χ$^{w}$ | χ$^{j}$ | χ$^{ʕ}$ |
| *pharyngealized* | χ$^{ʕw}$ | — | |

Table 2.50: Voiceless uvular fricative

| / χː / | *Labialized* | *Palatalized* | *pharyngealized* |
|---|---|---|---|
| *Base* | χː$^{w}$ | — | χː$^{ʕ}$ |
| *pharyngealized* | — | — | |

Table 2.51: Voiceless long uvular fricative

| / ʁ / | *Labialized* | *Palatalized* | *pharyngealized* |
|---|---|---|---|
| *Base* | ʁ$^{w}$ | ʁ$^{j}$ | ʁ$^{ʕ}$ |
| *pharyngealized* | ʁ$^{ʕw}$ | — | |

Table 2.52: Voiced uvular fricative

| / ʁː / | *Labialized* | *Palatalized* | *pharyngealized* |
|---|---|---|---|
| *Base* | — | — | — |
| *pharyngealized* | — | — | |

Table 2.53: Voiced long uvular fricative

| / ħ / | *Labialized* | *Tense/Long* |
|---|---|---|
| *Base* | ħʷ | ħː |

Table 2.54: Voiceless pharyngeal fricative

| / ʕ / | *Labialized* | *Tense/Long* |
|---|---|---|
| *Base* | ʕʷ | — |

Table 2.55: Voiced pharyngeal fricative/approximant

| / ʡ / | *Labialized* | *Tense/Long* |
|---|---|---|
| *Base* | ʡʷ | |

Table 2.56: Epiglottal stop

| / ʜ / | *Labialized* | *Tense/Long* |
|---|---|---|
| *Base* | — | ʜː |

Table 2.57: Voiceless epiglottal fricative

| / ʢ / | *Labialized* | *Tense/Long* |
|---|---|---|
| *Base* | — | ʢː |

Table 2.58: Voiced epiglottal fricative

| / ʔ / | *Labialized* |
|---|---|
| *Base* | ʔʷ |

Table 2.59: Glottal stop

| / h / | *Labialized* | *pharyngealized* |
|---|---|---|
| *Base* | $h^w$ | $h^ʕ$ |

Table 2.60: Voiceless glottal fricative

| / ɦ/ | *Labialized* |
|---|---|
| *Base* | — |

Table 2.61: Voiced glottal fricative

The gaps in these tables reveal generalizations about the types of post-velar consonants that are attested. One small gap is that among the uvulars, /q, χ, ʁ/ can be palatalized, but no language contains palatalized /ɢʲ/. This is likely an accidental gap since /ɢ/ is rare even among languages with post-velars. In addition, there are no doubly-articulated consonants, e.g. /k͡p/, that use a consonant with a uvular articulation.[44]

A larger generalization is that while uvular stops can combine labialization, pharyngealization, and ejection, a consonant cannot combine any of pharyngealization, palatalization, or prenasalization. One reason a consonant cannot be both pharyngealized and palatalized may be that the two are articulations are inherently antagonistic. This assumes, incorrectly, that pharyngealization always involves tongue root retraction, and further that this is necessarily antagonistic with palatalization. This also seems to be incorrect, since pharyngeals can be produced with the "double bunching" articulation that involves both a posterior and anterior constriction. This suggests that the reason why pharyngealization and palatalization are incompatible is perceptual. The reason why pharyngealization and prenasalization cannot combine is also likely perceptual. Nasality has been shown to occur with pharyngeal consonants in Moroccan Arabic as an enhancing feature (Zellou 2012:157-159). Because nasalization enhances the perception of a consonant as pharyngeal, it is unlikely that listeners could distinguish secondary nasalization and pharyngealization on a single segment to differentiate that segment from one that is only pharyngealized.

[44]Some click consonant clusters that include a uvular consonant incorporate that consonant as the posterior articulation in the click, rather than using a velar articulation (Florian Lionnet, p.c.).

#### 2.3.2.1 Other Very Rare Post-Velar Consonants

| *Phoneme* | *Description* | *Languages* |
|---|---|---|
| ɢ͡ʁˀ | Glottalized voiced uvular affricate | West !Xõo |
| ʛ̥ | Voiceless uvular implosive | Q'anjob'al |
| ʛ | Voiced uvular implosive | Mam |
| ʀ | Uvular trill | Japreria, Xiriâna |
| ʀ̥ | Voiceless uvular trill | Kurukh |
| ɴ | Uvular nasal | Japanese, several Arawak lgs. |
| ˀɴ | Glottalized uvular nasal | Klallam |

Table 2.62: Other attested uvular consonant phonemes

A voiced uvular affricate is attested only in West !Xõo, where it occurs only in a glottalized form, /ɢ͡ʁˀ/ (Naumann Forthcoming:4,7). The uvular implosives (/ʛ̥, ʛ/) is attested in the Mayan languages Q'anjob'al (as voiceless, according to Shosted 2009) and in Mam (presumably as voiced).

The uvular trill is attested as the only guttural consonant in two South American languages, Japreria (Carib; Oquendo 2004) and Xiriâna (Arawak; Michael et al. 2012), as well as in the Dravidian language Kurukh (Gordon 1976). In Kurukh (Dravidian), its main realization is claimed to be voiceless (Gordon 1976:15).

The uvular nasal /ɴ/ is reported for Japanese (Okada 1991:94), a number of South American Arawakan languages (Michael et al. 2013), the Iwellemmeden and Ayr varieties of Tuareg Berber (Prasse et al. 1998), and Klallam (Montler 1998). In Klallam, a glottalized uvular nasal is listed as well. Based on the realization of glottalized sonorants in the Pacific Northwest, this has been interpreted as a pre-glottalized uvular nasal (/ˀɴ/).

Finally, in Khwarshi, all dialects except the standard one appear to contrast /ħ/ with both /h/ and pharyngealized /hˤ/ (Khalilova 2009:16-17). However, from the examples given, it is unclear whether the /hˤ/ is an independent phoneme or an /h/ with suprasegmental pharyngealization spread onto it. The non-standard dialects also contain simultaneously pharyngealized and nasalized vowels that contrast with modal vowels, pharyngealized vowels, and nasalized vowels (16, 24). This makes it one of the only languages outside of the Kalahari to have vowels that can be simultaneously pharyngealized and nasalized.

## 2.4 Areal Patterns

### 2.4.1 Areas in Which Post-Velars Are Uncommon

With the exception of glottals, post-velar consonants are comparatively rare and their distribution is uneven. While the languages of some areas, such as the Caucasus, are particularly rich in post-velar consonants, other areas have far fewer languages with non-glottal post-velar consonants than would be expected.

Very few languages of the area east of the Rocky Mountains in the United States and subarctic Canada have non-glottal post-velar consonants. One notable exception is Sioux, which has /χ, ʁ/ as the counterparts of its velar stop series (Lakota, Dakota; Rood and Taylor 1996:441).

Another area in which very few languages with post-velar consonants exist is the rest of South America outside of the Andes and the Gran Chaco, which includes much of Amazonia, Brazil, and northern South America. In this area, only three languages are reported to contain a post-velar consonant, and all contain only a single uvular. One of these languages is Avá-Canoeiro, a Tupí-Guaraní language spoken in the southern part of the Brazilian state of Tocantins. Its only post-velar consonant, as well as its only fricative, is /ʁ/, which is realized both as [ʁ] and [ɢ] (Borges 2006:50-1). Another language with a non-glottal post-velar consonant is Xiriâna, an Arawak language spoken in the Brazilian state of Amazonas, which has only the uvular trill, /ʀ/ (Michael et al. 2012). Japreria (Carib), spoken in the mountains of northwestern Venezuela west of Maracaibo, also has a uvular trill as its only non-glottal post-velar consonant (Oquendo 2004).

Subsaharan Africa, excluding the southern African cluster identified above, is also a place where few post-velar consonants occur. The Bantu language Shekgalagari has uvular stops that contrast with velar stops. Although it is tempting to view this contrast, which is rare for Bantu, as a contact effect based on Shekgalagari's location in the Kalahari Basin, the uvular stops seem to have arisen as the result of sound changes that backed the articulation of many consonants (Larry Hyman, p.c.). Another Bantu language, Nyaturu, that is spoken in the Tanzanian Rift Valley developed /ʁ/ as "a regular reflex of Proto-Bantu **g*" most likely under the influence of the West Rift Cushitic languages and the nearby Nilotic language Datooga (Kiessling et al. 2007:196). Datooga itself opposes /k/ with a uvular phoneme, which can be denoted /q/, which is realized variably as [q, ɢ, χ], or [ʁ] (195). The opposition arose "as the result of a split of the original proto-phoneme **k* [...] conditioned by the ATR quality of surrounding vowels with original **k* retained in [+ATR] environment and shifted to the uvular in [-ATR] environment" (Kiessling et al. 2007:195).

In West Africa, the Senufo languages have post-velar consonants, including a uvular flap allophone of /g/ in Supyire and a full pharyngeal phoneme /ʕ/ in Minyanka. In Supyire, a uvular flap occurs as an allophone of /g/ in unstressed, non-initial syllables (Carlson 1994:10). Minyanka has a pharyngeal phoneme, /ʕ/, that corresponds to the /ʔ/ of other Senufo languages (Dombrowsky-Hahn 1999:56). The sound [ʕ] in Minyanka occurs not only as an independent phoneme, but as an allophone of /g/ between identical low or mid-low vowels (52). It is also interesting that no other post-velar consonants whatsoever exist in Minyanka, either as phonemes or allophones (51). Outside of the Senufo languages, but still in West Africa, Wolof (Atlantic) has uvular consonants, and opposes /q/ and /k/ (Bell 2003:4-5).

A striking distributional fact is that there are no uvular or pharyngeal consonants in any language natively spoken on the Australian continent. Out of the over 350 indigenous languages of Australia (Bowern 2011), not one contains a uvular or pharyngeal consonant, although some languages do have glottal phonemes (Gasser and Bowern 2014:4-5; Dixon 2002:615). Looking to Papua New Guinea, I am not aware of any language with a pharyngeal consonant, but some languages, such as Kunimaipa (Pence 1966), contain at least one uvular consonant. Uvular and pharyngeal consonants are also rare throughout the Austronesian stock outside of Taiwan.

### 2.4.2 Correlations with Spread Zones and Residual Zones

It is an open question whether the uneven geographic distribution of languages with post-velar consonants can be explained. The survey presented here is structured around the observation that large geographic zones contain stocks with languages that contain post-velar consonants. Nichols (1992:13 et passim) identifies a way of characterizing such large geographic clusters of languages, usually on the scale of a subcontinent, as either spread zones or residual zones on the basis of historical and typological factors. I propose here that the the presence of (non-glottal) post-velar consonants in a language may correlate positively with that language being in a residual zone.

Nichols (1992:16-17) defines a spread zone as an area with "little genetic diversity" where "often, a single language family dominates the spread zone." Furthermore, spread zones often exhibit a "rapid spread of languages or language families" with "consequent language succession" in which a spreading language displaces the language(s) of the territory it spreads into (17). A residual zone is considered the opposite of a spread zone. A residual zone typically occupies an area of equal or lesser size in which there is "high genetic density, significantly higher than the overall density of the host continent, often an order of magnitude higher" (21). Unlike in a spread zone, there is usually "no appreciable spread of languages or families" or "language succession," and consequently there is often "accretion of languages and [a] long-term net increase in diversity" (ibid.).

Another characteristic that separates spread zones and residual zones is the time-depth of the linguistic stocks spoken there. Linguistic stocks in spread zones typically show a "shallow" time-depth of diversification (17) while stocks in residual zones often show a "deep" time-depth of diversification (21). Abstracting from this statement, languages in spread zones can be thought of as being in some sense 'younger' than languages in residual zones. Languages in residual zones have diversified *in situ*, often to a greater extent than languages in spread zones. Therefore, if post-velars are found more often in residual zones than in spread zones, one can infer that a greater number of changes is required for post-velars to arise. However, another possible interpretation is that post-velars are less likely to be lost in residual zones. No matter which interpretation is ultimately correct (or if both are correct), it is worth examining the correlation of the distribution of languages with post-velars with whether the language is in a spread zone or residual zone.

Nichols (1992:17-20, 26) identifies eleven spread zones:

1. Western Europe
2. The Eurasian Steppe
3. The Ancient Near East
4. Saharan North Africa
5. Central Sub-Saharan Africa
6. Central Australia
7. Central Insular Oceania

8. The Arctic Region
9. The Great Basin of North America
10. Interior North America
11. Mesoamerica

As can be seen from the discussion in §2.4.1, in many of these spread zones, languages with post-velars are very rare. Western Europe has very few post-velars, and the development of uvular 'r' (/ʁ/) occurred within the past millennium. Post-velars are also extremely rare in Central Sub-Saharan Africa, Central Insular Oceania, the Great Basin of North America, Interior North America, and they are non-existent in Australia. However, post-velars are present throughout the Near East and Saharan North Africa due to the spread of Arabic and Berber, and are present in the Arctic Region due to the spread of languages in the Eskimo-Aleut stock. This means that post-velar consonants are common in only three out of eleven spread zones and are the result of the spread of only three stocks (Semitic, Berber, and Eskimo-Aleut). One might also take the area occupied by the Tupí-Guaraní and Macro-Ge languages to be a spread zone, and these languages also exhibit no post-velars (except for Avá-Canoeiro, which has /ʁ/).

The prevalence of post-velars is much greater in residual zones. The residual zones identified by Nichols (1992:21-) are:

1. "a part of eastern Africa here represented by Ethiopia and Kenya" (Greater Abyssinia to the Tanzanian Rift Valley in this study)
2. The Balkans
3. The Caucasus
4. The Pamir-Himalaya Region
5. The Pacific Coast of Northern Asia
6. The Southeastern United States
7. Papua New Guinea
8. Northern Australia
9. The Pacific Coast of North America (including California)

An additional residual zone is the Kalahari Basin (Güldemann 1997:26). Nichols (1992:21) also notes that "presumably parts of South America" are residual zones. It is tempting to view the Andes, as defined here, as a residual zone. However, an examination of the distribution and genealogical diversity of languages in South America indicates a possible residual zone in northwestern South America in the Andes and the areas immediately in contact with them from the Vaupes Region to approximately the Peruvian-Ecuadorian coastal border.[45] Given the spread of the Quechua and Jaqi (Aymaran) stocks, the Altiplano region of the Andes may well be a spread

[45]The map display for the South American Phonological Inventory Database (SAPhon) at `http://linguistics.berkeley.edu/∼saphon/en/` was used to do this examination.

zone. It is uncertain whether the Gran Chaco, as delineated here, is a residual zone. It is occupied by the Guaicuru and Mataco stocks, along with the isolate Vilela and at least two Tupí-Guaraní languages.

Most of the languages of five residual zones, Greater Abyssinia to the Tanzanian Rift Valley, the Caucasus, the Pacific Coast of Northern Asia, the Pacific Coast of North America, and the Kalahari Basin, contain post-velars. That is five out of ten of the residual zones identified. While this is not a majority of the residual zones, more residual zones than spread zones contain post-velar consonants. Moreover, in the residual zones in which they occur, post-velar consonants not only occur, but are common, and are attested in multiple stocks within the zone. Because residual zones by definition have greater linguistic diversity, they contain larger numbers of languages than spread zones, which means that statistical tests are necessary to establish whether the concentration of languages with (non-glottal) post-velar consonants in residual zones is not due to chance.

The most fascinating correlation, which must remain speculative at this point but invites further investigation, is the correlation between geographic clusters of languages with post-velar consonants and proposed patterns of human migration into the Americas. Post-velar consonants occur in languages of the Pacific North Coast of Asia, the Pacific Northwest Coast of North America, and throughout the Andes all the way to Tierra del Fuego. This distribution roughly traces the Pacific Coast from approximately Japan to Tierra del Fuego, which approximates (at least from the Bering Strait southward) the standard proposed route for the original peopling of the Americas, with groups moving down the western coast and then moving eastward.

While Mesoamerica contains relatively few languages with post-velar consonants, it is a spread zone in which languages without post-velars could displace original languages that had them (or could have developed them). The residual zone very tentatively suggested here in Northwest South America is also a counterexample with very few languages there exhibiting post-velar consonants.

The prevalence of post-velar consonants in residual zones and the possible correlation between the distribution of post-velars and the original peopling of the Americas can be seen, if true, as evidence that post-velar consonants develop from languages that have been able to develop in place for deep time-depths. Post-velar consonants occur most frequently in languages in residual zones, and the stocks in residual zones often show a "deep" time-depth of diversification (Nichols 1992:21), indicating that they have been in that area for a very long time. In the Americas, post-velar consonants occur most often in languages along the western portion of the two continents, which is where languages are presumed to have existed for the longest time based on the standard proposed route of original migration. These facts, combined with the cross-linguistic rarity of uvular and especially pharyngeal/epiglottal consonants, point to post-velar consonants arising only after long periods of *in situ* development.

## 2.5 Summary and Conclusions

This chapter surveyed the phonemic inventories of 322 languages in geographic areas known to contain linguistic stocks with languages rich in post-velar consonant phonemes. This survey contained the majority of the languages in which pharyngeal consonants occur and which contain the most elaborated inventories of uvular consonants. The results of the survey showed which post-velar consonants are cross-linguistically attested, which forms the basis for the new featural representation that will be proposed in chapter 4. The results also showed the commonality of various combinations of post-velar places of articulation in the languages in the survey, with the result that languages with only pharyngeals and no uvulars or glottals are extremely rare, as are languages with uvulars and pharyngeals but not glottals. I propose that this distribution shows that pharyngeals are likely to develop from uvulars in languages that contain both uvulars and glottals already.

After presenting the results of the main survey, the chapter considered several questions that require further research. The first is whether the geographic distribution of post-velar consonants can be correlated with residual zones. This question must be answered using statistical tests and is related to the question of whether post-velar consonants spread as an areal feature. The methods used in Haynie (2012) may be appropriate for answering this latter question. It should be noted that in a study of which typological features might be Circum Pacific areal features, Bickel and Nichols (2006) found that having a uvular consonant or series of uvular consonants was likely not an areal feature. The next question was whether the distribution of post-velar consonants can also be correlated with the original north to south human migration into the Americas. This idea must remain speculative, but it is related to how uvulars and pharyngeals arise. Understanding more about the genesis, persistence, and loss of post-velar consonants is necessary before progress can be made in answering these questions.

# Chapter 3

# Phonological Patterns Involving Post-Velar Consonants

The previous chapter surveyed geographic areas with stocks which were known to contain languages with post-velar consonants. This chapter presents the result of surveying those same languages for sound patterns (phonological processes or distributional constraints) that involve post-velar consonants and show unique phonological effects. These results show which aspects of post-velars' phonological behavior must be accounted for in phonological theory. These sound patterns also demonstrate the kinds of phonological classes to which the post-velar consonants belong, which are more diverse than might be expected based on the proposal that there is an innate guttural natural class that encompasses all post-velar consonants (McCarthy 1994). The phonological classes involved in the sound patterns presented here are the object of explanation for a new system of deriving natural classes presented in chapter 5 and exemplified in chapter 6.

The present chapter first examines local effects on vowels (§3.1), showing that while systematic lowering by post-velars is common, systematic backing is not. In addition, vowel fronting and even consonantal palatalization caused by pharyngeals is well attested. Next, post-velar harmonies are surveyed in §3.2. In §3.3, other phonological processes that are attested, but less common are surveyed, including co-occurrence restrictions, guttural transparency, degemination, deletion, and contrast neutralization.

## 3.1 Local Effects on Vowels

The post-velar consonants have a range of phonetic effects on adjacent vowels. These effects and the sets of post-velar consonants that condition them have been cited frequently as evidence for particular phonological representations of the post-velar consonants. The effects that post-velar consonants have on vowels include effects that change the vowel's quality, sometimes so much so that phonemic contrasts are neutralized. Post-velars also cause effects that are unrelated to a vowel's quality, including laryngealization and lower pitch.

The most common effect is lowering, which can apply systematically to all the non-low vowels in a language's inventory. Lowering can occur next to all post-velar consonants. Backing is also attested, but is less common than lowering and tends to occur more next to uvulars than pharyngeals. Lowering and backing effects are typically non-neutralizing and occur at the phonetic level, presumably as a result of co-articulation, both anticipatory and perseveratory. Non-neutralizing lowering effects are discussed in §3.1.1, followed by neutralizing effects in §3.1.2, and backing as a whole in §3.1.3. Vowel fronting occurs in contact with pharyngeal/epiglottal consonants, but not in contact with uvular consonants, and the sound patterns that exemplify this are presented in §3.1.4. Pharyngeal consonants, again to the exclusion of uvulars, can introduce epenthetic vocalic offglides (§3.1.5), cause neighboring vowels to be laryngealized or creaky (as in Nuuchahnulth and Achumawi; §3.1.6), and can even induce lower pitch on preceding vowels (§3.1.7).

### 3.1.1 Non-Neutralizing Lowering

In Tiberian Hebrew (i.e. the Tiberian pronunciation of Biblical Hebrew), plural nouns have their leftmost vowel reduced to /ə/ (unless the vowel was /o/), and contact with a pharyngeal or laryngeal consonant actively lowers /ə/ to [ă] ("a-colored schwa"; McCarthy 1994:209).

(4) Normal pluralization (McCarthy 1994:209)
/melek/ + PL → /məlaːkiːm/ 'king'
/qeber/ + PL → /qəbaːriːm/ 'grave' (no effect of a uvular)
/seːper/ + PL → /səpaːriːm/ 'book'
/qoːdeʃ/ + PL → /qŏdaːʃiːm/ 'holiness' (no effect of a uvular)

(5) Pluralization with an initial guttural (ibid.)
/ʔeben/ + PL → /ʔăbaːniːm/ 'stone'
/hebel/ + PL → /hăbaːliːm/ 'vapor'
/ʕeːder/ + PL → /ʕădaːriːm/ 'flock'
/ħeder/ + PL → /ħădaːriːm/ 'room'
/ħoːdeʃ/ + PL → /ħŏdaːʃiːm/ 'month'

Note that the uvular stop /q/ does not affect vowels in this process and thus patterns differently than the pharyngeals and glottals.

In a process called regressive lowering in at least five of the Interior Salish languages, uvulars and pharyngeals lower preceding vowels (Bessell 1998b:125-128). In Thompson (Nlaka'pamux) and Lillooet (St'at'imcets), /z/ and /zˀ/ are also able to retract the same vowels, except for /i/. The process is strictly local, with all consonants acting as blockers except for the glottal stop /ʔ/ in Moses-Columbia (Nxaʔamxcín) and Lillooet (Bessell 1998b:128). Table 3.1 shows the effects of regressive lowering on vowels immediately preceding uvulars and pharyngeals. Not all the languages have all the vowels of the table in their underlying inventories. If a retracted equivalent is not listed, it should be assumed that the language does not have the corresponding underlying vowel.

| | / i / | / u / | / e / | / æ/ | / ə/ | / a / |
|---|---|---|---|---|---|---|
| Colville-Okanagan | ɪ | o | | | | ɑ |
| Moses-Columbia | ɛ | ɔ | | | ʌ | ɑ |
| Thompson | e | o | æ | | ʌ | |
| Lillooet | ɛ | ɔ | | a | | |
| Shuswap | ɪ/ɛ | ɔ | æ/a | | | |

Table 3.1: Effects of proceeding uvulars and pharyngeals on vowels in five Interior Salish languages (adapted from Table 1 in Bessell 1998b:128)

Filomeno Mata Totonac lowers vowels from high to mid when they are adjacent to uvulars and to some occurrences of the glottal stop /ʔ/. The uvular segments include the phoneme /q/ (which contrasts with /k/) and the uvular allophones of /x/ and /n/ that result from uvular harmony and assimilation, respectively (McFarland 2009:35-37). Adjacent to uvulars, whether phonemic or phonetic, high vowels always lower.[1] The following examples are from McFarland (2009:36).

(6) Lowering adjacent to /q/

a. /qiilḁ/ → [qeel’a]
atole ‘type of atole’

b. /piʃ-luquti/ → [piʃˈloqotʰi]
neck-bone ‘throat’

c. /t͡sit͡siqi̥/ → [t͡siˈt͡seqʰe̥]
black ‘black’

d. /lii-quqa/ → [leeˈqoqʰḁ] / [lɛæˈqoqʰḁ]
INSTR-carry ‘carrying cloth (for babies)’

(7) Lowering adjacent to /x/ as the harmonized allophone [χ]

a. /quxuu-nan/ → [qoχooˈnun]
cough-IND.OBJ ‘s/he coughs’

(8) Lowering adjacent to /n/ as the assimilated allophone [ɴ]

a. /siliinqi/ → [ˈsileeɴqʰe̥]
cricket ‘cricket’

b. /spupunqu̥/ → [spuˈpoɴqʰo̥]
blue ‘blue’

The glottal stop can also lower high vowels. Vowels are always lowered next to the glottal stop when it appears in “certain affixes and a small number of function words” including “the prefixes *ti-* COUNTEREXPECTATIONAL and *tuu=* ‘who’; [the] suffixes *-qeʔe* MEANWHILE and *-qoʔo*

[1]McFarland (2009:36) notes that “With the instrumental prefix *lii-*,” as shown in example (6d), “the vowel, and especially the mora closest to the uvular, may be lowered further, with a phonetic realization close to *ɛæ*.”

TOTALITIVE; and *noʔo* 'now' and *t͡ʃoʔo* 'and' (all with high vowels underlyingly)" (McFarland 2009:36). Across all contexts, glottal stop only sometimes lowers adjacent high vowels.

(9) Lowering of high vowels adjacent to glottal stop in morphological contexts in which it regularly occurs (McFarland 2009:37)

a. /ʃ-ti-an/ → [ʃteˈʔan]
PAST-CNTR-go 'she should have gone'

b. /tuu=an/ → [tooˈʔan]
who-go 'he who goes'

It should be noted that Filomeno Mata Totonac represents a direct counterexample to the claim in (Rose 1996:98) that "a contrast between the uvular stop and laryngeals should not invoke a Pharyngeal node on laryngeals" as would a contrast between laryngeals and at least one uvular fricative. This is discussed in further detail in §4.3.2.5.

Another example of phonetic lowering adjacent to a post-velar consonant comes from Huallaga Quechua, in which high vowels lower to mid in contact with /q/ (Weber 1989:458).

(10) High vowel lowering in Huallaga Quechua[2]

a. /i/ → [e] / {__q, q__}
/q**i**pi/ → [g**é**pi] 'bundle' (458)

b. /u/ → [o] / {__q, q__}
/aq**u**/ → [ág**o**] 'sand' (452)
/s**u**qta/ → [s**ó**χta] 'six' (458)

Huallaga Quechua /q/ is also able to lower high vowels across an intervening coda sonorant, but not across other consonants (ibid.).

(11) High vowel lowering across a coda sonorant in Huallaga Quechua
/pirqa/ → [pérga] 'wall'
/p**i**t͡ʃqa/ → [p**í**t͡ʃga], *[p**é**t͡ʃga] 'five'
/**i**squn/ → [**í**sgoŋ], *[**é**sgoŋ] 'nine', note the regular application of lowering where it is not blocked by an intervening obstruent
/sh**u**nqu/ → [sh**ó**ŋgo] 'heart'
/**u**ʎqu/ → [**ó**ʎgo] 'male', note the application of high vowel lowering in both licit environments

A similar lowering process (which may have applied only before coda /q/) led to the genesis of phonemic mid vowels in the native Quechua vocabulary stratum in Cochabamba Quechua (spoken in Bolivia; Weber 2005:12 citing de la Rocha 1987:34). A sound change merged coda */k/ and */q/ to /x/, and the contrast between words differentiated solely in this respect was shifted to the preceding vowel, leading to minimal pairs in the native lexical stratum.

[2]The allophony of underlying /q/ is described in Weber (1989:452). Weber notes that "/q/ is rarely pronounced as a voiceless stop in HgQ [Huallaga Quechua] as it is in most other dialects" (ibid., fn. 4). The actual status of /q/ as an underlying uvular is certain on the basis of comparison with other Quechua varieties and its allophony differing from that of velar /k/. In the examples, stress is indicated on the penultimate syllable with an acute accent.

(12) High vs. mid vowel minimal pairs in Cochabamba Quechua (from Weber 2005:12, citing de la Rocha 1987:34)

a. t͡ʃixt͡ʃi ‘hail’ vs. t͡ʃext͡ʃi ‘pleasant’

b. suxta ‘right away’ vs. soxta ‘six’
suxya ‘change of appearance’ vs. soxya ‘run’

In Aymara and Jaqaru (both Jaqi), which are unrelated to Quechua but both geographically also Andean, the high vowels /i/ and /u/ also lower to [e∼ɛ] and [o∼ɔ], respectively, in contact with uvulars (Hardman et al. 1988:38; Hardman 1983:83). In Aymara, though, the lowering effect of the uvular on /i/ can be mitigated to [ɪ] (rather than [ɛ]) if the /i/ is after palatal /ɲ/ or /j/.

(13) Aymara vowel lowering in contact with a uvular (Hardman et al. 1988:32-38)

| | | |
|---|---|---|
| /uqi/ | [ɔqɛ] | ‘gray’ |
| /quqa/ | [qɔqa] | ‘tree’ |
| /hiwq’i/ | [hiwq’ɛ] | ‘smoke’ |
| /q’aq’usiɲa/ | [q’aq’ɔsiɲa] | ‘to support and scratch oneself against something’ |
| /t͡ʃaχi/ | [t͡ʃaχɛ] | ‘cold’ |
| /t͡ʃ$^h$uχu/ | [t͡ʃ$^h$ɔχɔ] | ‘urine’ |

(14) Aymara vowel lowering in contact with a uvular being mitigated by contact with a palatal (Hardman et al. 1988:38)
/ɲ**i**q’i/ → [ɲ**ɪ**q’ɛ], *[ɲ**ɛ**q’ɛ], *[ɲ**i**q’ɛ] ‘mud’

(15) No lowering adjacent to velars or glottals in Aymara (33)

| | | |
|---|---|---|
| /kusa/ | [kusa] | ‘good, well, excellent’ |
| /hikisiɲa/ | [hikisiɲa] | ‘to meet someone, find something’ |
| /k$^h$usu/ | [k$^h$usu] | ‘thick (of liquids)’ |
| /k’usa/ | [k’usa] | ‘chicha (beverage made of quinoa, corn, etc.)’ |
| /hiwk’i/ | [hiwk’i] | ‘toaster’ |
| /t͡ʃahitu/ | [t͡ʃahitu] | ‘to set ones teeth to drink something too cold or too hot’ |
| /hup$^h$a/ | [hup$^h$a] | ‘quinoa’ (edible grain) |

In Aymara, this mitigating effect, which can be seen as partial blocking, seems to be limited to /i/. However, in Jaqaru, any high vowel (both /i/ and /u/) preceded by a uvular and followed by a palatal (which are understood to include the post-alveolar affricates, palatals, and alveolo-palatals) will remain fully high. That is, the lowering effect of the uvular consonant is completely blocked, not just partially.

(16) Jaqaru vowel lowering in contact with a uvular (Hardman 1983:40-41)

| | | |
|---|---|---|
| /iqu/ | [eqo] | ‘little girl’ |
| /qut͡ʂa/ | [qot͡ʂa] | ‘lake’ |
| /ʎuq’i/ | [ʎoq’ɛ] | ‘(walking) cane, stick’ |
| /haʎq’u/ | [haʎq’o] | ‘dog’ |
| /p$^h$aq$^h$i/ | [p$^h$aq$^h$ɛ] | ‘type of pocket in the chest of women’s typical dress’ |
| /uq$^h$u/ | [oq$^h$o] | ‘mud’ |

(17) Jaqaru vowel lowering in contact with a uvular being blocked by contact with a palatal (Hardman 1983:43)
/ɲuːq’u/ → [ɲuːq’o] ‘hock leather’
/qaq**u**t͡ʃu/ → [qaq**ú**t͡ʃo] ‘parrot’[3]

The mitigation of the effect of uvulars by palatals (including palatals proper, alveolo-palatals, and post-alveolars) in Aymara and Jaqaru are examples of the antagonistic relationship between palatal (with a high, front lingual articulation) and post-velar segments with a posterior tongue body articulation. However, this antagonistic relationship can be surmounted, as demonstrated by the palatalized uvular phonemes in some Northwest Caucasian languages. Furthermore, it will be shown in §3.1.4 that it is the backing articulation of the tongue dorsum, not post-velar articulations in general, that is antagonistic to high, front lingual articulations.

### 3.1.2 Neutralizing Lowering

In the sound patterns in the previous section, the lowered vowels did not phonetically overlap with any other phonemes, meaning that they never caused neutralization of a phonemic contrast. The sound patterns reviewed in this section do involve such overlap and lead to neutralizations of contrast in specific environments.[4]

In Tamashek (Berber stock; Taneslemt variety), especially in the Timbuktu area near Kal Ansar, “the consonants /r, q, ʁ, χ, ʕ, ħ/, all pharyngealized alveolars /d$^ʕ$, t$^ʕ$, l$^ʕ$, s$^ʕ$, z$^ʕ$/, and to some extent /h/, hereafter ‘backing and lowering consonants’ . . . , have the effect of lowering preceding high full vowels and of backing and lowering short vowels” (Heath 2005:35).[5] In this process, /i/ → /e/, /u/ → /o/, and /ə/ → /æ/. The process is phonological rather than phonetic. It “is systematic and results in surface mergers of vocalic phonemes” (ibid.). When these backing and lowering consonants are “not syllable-final, there is still a notable backing or lowering effect, but complete phonemic merger does not always occur” (ibid.).

[3]The lowering of word-final /u/ in this example is unrelated to the lowering effect of uvulars.

[4]The sound patterns of the previous section can be termed non-structure preserving since they introduce non-underlying segments, and the patterns of this section can be considered structure preserving, since they do not generate vowels that do not occur as underlying phonemes.

[5]One could argue on the basis of this process that the backing and lowering consonants form a guttural natural class in Tamashek. Also, the variety of Tamashek described in Heath (2005) appears not to have the kind of far-spreading, prosodically-defined emphasis harmony of Berber languages like Tashlhiyt in which emphasis can spread throughout a syllable and even a word (Boukous 2009).

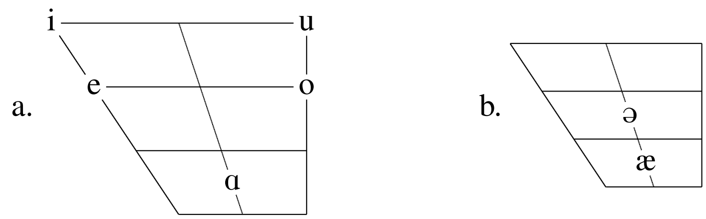


Figure 3.1: The Tamashek (Berber) phonemic full (a.) and short (b.) vowel inventory (Heath 2005:34)

When the backing and lowering consonants occur as the second member of a cluster, they are still able to affect the vowel preceding the cluster as if it were affected by an onset backing and lowering consonant. Only secondarily pharyngealized consonants appear to be able to spread these effects. Primary post-velar consonants, like /q, ʁ, ʕ/, are generally not able to do this, except in the case of /ŋʁ/. It should be noted that only certain consonants, namely non-rhotic sonorants, can be the first members of the cluster.

(18) Clusters which transmit non-phonemic backing and lowering effects in Tamashek (Berber), grouped by first member of the cluster (Heath 2005:35; acute accents mark stress)

a. /m/ : mbˤ, mdˤ, mzˤ
/t-**é**mbˤe/ → [t**ɛ́**mbˤe] and
variant /t-**é**mdˤe/ → [t**'ɛ**mdˤe] 'taste'
/t-**í**m-zˤ-əzˤzˤij-/ → [t**ɛ́**mzˤ. . . ] 'pull each other'[6]

b. /n/ : ndˤ, nzˤ
/**ə́**ndˤəw/ → [**á**ndˤu] 'throw!'
/**ə́**nzˤəj/ → [**á**nzˤəj] 'blink!'

c. /ŋ/ : ŋʁ
/**ə́**ŋʁe-q-q/ → [**á**ŋʁɛqː] 'I killed him'

d. /l/ : ldˤ, lzˤ
/**ə́**ldˤæʃ/ → [**á**ldˤæʃ] 'become tired'
/**ə́**lzˤɑ/ → [**á**lzˤɑ] 'shave'

(19) Clusters which block non-phonemic backing and lowering effects in Tamashek (Berber), grouped by first member of the cluster (Heath 2005:35)

a. /m/ : *mʁ, *mq, *mʕ

b. /l/ : *lʁ, *lq, *lʕ
e.g. /**ə**lqəbíl-æt/ → [**ə**lqəbíl-æt] 'tribe' (*[**a**lqəbíl-æt])

[6]The rest of the form is not indicated in the source, but would presumably be [t**ɛ́**mzˤæzˤzˤɛj].

(20) Summary of transmission of backing and lowering effects across clusters

| C1↓ / C2→ | bˤ | dˤ | zˤ | q | ʁ | ʕ |
|---|---|---|---|---|---|---|
| m | ✓ | ✓ | ✓ | | | |
| n | | ✓ | ✓ | | | |
| ŋ | | | | | ✓ | |
| l | ✓ | | ✓ | | | |

In Arabic, 'guttural lowering' processes cause both high vowels, /i/ and /u/, to become the low vowel /a/ (McCarthy 1994:207-213). These processes are not necessarily neutralizing, but they are fully a part of the synchronic grammar of the language. One such process is that guttural consonants (/χ, ʁ, ʕ, ħ, ʔ, h/) adjacent to the thematic vowel of imperfect verbs cause that thematic vowel to become /a/ (McCarthy 1994:207).[7] Another example of a guttural lowering process is that in 'Anaiza Bedouin Arabic (Saudi Arabia) in which a regular rule raises /a/ to /i/ in open syllables, but the application of the process is blocked by a preceding guttural consonant (McCarthy 1994:212 citing Johnstone 1967).

(21) Blocking of raising to /i/ after a guttural in 'Anaiza Bedouin Arabic (Saudi Arabia)

a. Regular raising
/k**a**tab/ → [k**i**tab] 'he wrote'
/b**a**gar/ → [b**i**gar] 'cows'

b. Blocking of raising
/ʔ**a**kal/ → [ʔ**a**kal] 'he ate' (*[ʔ**i**kal])
/h**a**batˤ/ → [h**a**batˤ] 'it (hair) became flat' (*[h**i**batˤ])
/ʕ**a**zam/ → [ʕ**a**zam] 'he invited' (*[ʕ**i**zam])
/ħ**a**suːd/ → [ħ**a**suːd] 'envious' (*[ħ**i**suːd])
/ʁ**a**buːg/ → [ʁ**a**buːg] 'evening milk' (*[ʁ**i**buːg])
/χ**a**zan/ → [χ**a**zan] 'he stored' (*[χ**i**zan])

In Kashaya (Pomoan; California), following a uvular, /i/ and /e/ lower to /a/, with /a/ remaining intact (Buckley 1994:105-113).

(22) Lowering of /i/ to /a/ (Buckley 1994:106)

a. /ʔusaq-in/ → /ʔusáːqan/ 'while washing the face'[8]
b. /ce-aq-in/ → /ceːqán/ 'while opening out from here'

(23) Lowering of /e/ to /a/ (ibid.)

a. /simaːq-et̪i/ → /simaːqat̪í/ 'although he's asleep'
b. /pʰi-ˀjaːq-ela/ → /pʰiʔjaːqalá/ 'I recognize it'

(24) Post-uvular /a/ remaining intact (ibid.)

---

[7]It is interesting to note that among the exceptions, "there are about twice as many … among the uvulars as there are among the pharyngeals" (ibid.).

[8]The acute accent marks stress.

a. /k$^{h}$unuːq-a$^{ʔ}$n-i/ → /k$^{h}$unuqaːdu/ ‘keep spoiling’

b. /$^{ʔ}$nu-$^{ʔ}$t̺’aq-ala-w/ → /duʔt̺’aqáːlaw/ ‘smear downward’

Following underlying /q$^{w}$/, the vowels /i, e, a/ neutralize to /o/ to create a surface sequence [qo] (not [q$^{w}$o] as might be expected; Buckley 1994:106-113).

(25) /i/ → /o/ / q$^{w}$__ (Buckley 1994:106)

a. /woq$^{w}$-in/ → /woqón/ ‘while flowing’

b. /ce-aq$^{w}$-in/ → /ceːqón/ ‘while opening out toward here’

(26) /e/ → /o/ / q$^{w}$__ (107)

a. /mo-maq$^{w}$-et̺i/ → /momáːqot̺i/ ‘although he ran in here’

b. /mo-aq$^{w}$-et̺i/ → /moːqot̺í/ ‘even though he ran out’

(27) /a/ → /o/ / q$^{w}$__ (ibid.)

a. /qaʃoːq$^{w}$-a$^{ʔ}$n-i/ → /qaʃoqoːdu/ ‘be getting well’

b. /mo-aloq$^{w}$-a$^{ʔ}$n-i/ → /moloːqodú/ ‘keep running up’

Dialects of Armenian (Indo-European) exhibit neutralizing lowering processes similar to those in Kashaya. The Agn dialect of Armenian has two uvular phonemes, /χ, ʁ/ and the rhotic /ɹ/ (transcribed as ‘ṙ’ in Vaux 1998), whose phonetic realization appears to be “retroflex, i.e. coronal and dorsal, [+back]” (Vaux 1998:185).[9] This study follows Vaux (1998:191) in assuming that this phoneme is phonetically the retroflex (rather than bunched) articulation of [ɹ]. In Agn, the high vowels /i/ and /u/ are lowered to /e/ and /o/, respectively, when they precede /ɹ, χ, ʁ/. Moreover, the phoneme /e/ has two allophones, tense [e] and lax [ɛ], and before /ɹ, χ, ʁ/, only lax [ɛ] is used. Thus, phonetically, [i, e] become [ɛ] and [u] becomes [o] before /ɹ, χ, ʁ/ (Vaux 1998:185).

(28) Lowering of /i/ and /u/ before /ɹ, χ, ʁ/ (Vaux 1998:185)

a. /ʃaɹviχ/ → *[ʃaɹveχ] → [ʃaɹvɛχ] ‘sprig’
/giʃiɹk$^{h}$/ → *[giʃeɹk$^{h}$] → [giʃɛɹk$^{h}$] ‘weight’

b. /g$^{h}$luχ/ → [gəloχ] ‘head’[10]
/gaguʁ/ → [gagoʁ] ‘soft’
/d$^{h}$uɹn/ → [d$^{h}$oɹ] ‘door’

[9]There is a basic division between the Armenian dialects, dividing them into eastern dialects which contrast /r/ and /ɹ/ and western dialects which have merged the two phonemes (Vaux 1998:7-8,16). The Agn dialect is western. For another western dialect, Homshetsma, Vaux (1998:191) describes ‘ṙ’ as being “pronounced in the same manner as underlying *r*—as well as American *r*—namely as a retroflex uvular glide [ɹ].” I interpret this to mean that the phoneme is pronounced like the retroflex variant of American /ɹ/: the front of the tongue is retroflected at the same time that a constriction in the pharyngeal region is made. In transcribing the Armenian prompts for a study with speakers of eastern dialects, Hacopian (2003:74) uses [ɹ] for the ‘ṙ’ phoneme. Note that Dum-Tragut (2009:19) describes Vaux’s ‘ṙ’ as an alveolar trill for eastern Armenian.

[10]Epenthesis in this form and deletion of /n/ in the form for ‘door’ are not relevant to the change being considered here.

Although /ɹ, χ/, and /ʁ/ all pattern together in the lowering process in Agn (as well as in blocking certain height changes in the Agulis, Kesab, Zeytun, and Homshetsma dialects, cf. Vaux 1998:187-188, 193), these phonemes do not always pattern together. In the Erznka dialect, "underlying *e* becomes *ɛ* before *ṙ* [ɹ; JCS], but not *χ* and *ʁ*" (Vaux 1998:183). This shows, first, that the uvulars need not condition the lax or [-ATR] allophone, [ɛ], of /e/, and, more importantly, that /ɹ/ need not pattern with the uvulars /χ, ʁ/ in Armenian. Similarly, data from the Homshetsma dialect shows that the uvulars can condition vowel changes to the exclusion of /ɹ/. In Homshetsma, the epenthetic vowel normally surfaces as [ɛ], but before the uvulars /χ, ʁ/ (and not /ɹ/), it surfaces as /a/ (Vaux 1998:192).

(29) Epenthetic vowel is [a] before /χ, ʁ/ in Homshetsma (Vaux 1998:192)[11]
/dʁa/ → [daʁá] 'boy'
/sχdor/ → [saχdór] 'garlic'

### 3.1.3 Vowel Backing

Non-neutralizing backing is much less common than that of lowering processes and appears to almost always be non-neutralizing. In addition, it happens in contact with both velars and post-velars. For example, in Kunimaipa (Goilalan; Papua New Guinea), the non-high vowels /e, o/, and /a/ back in contact with /k/ and /ʁ/ (Pence 1966:62-63). However, high vowels lower instead of backing when they occur in the same environment.

Another case of non-neutralizing backing, of which more will be made later, is of /a/ to [ɑ] in contact with "emphatic" (uvularized) consonants in Cairene Arabic (Watson 2002). The low vowel /a/ is also backed to [ɑ] in contact with uvulars in the South American languages Jaqaru (Jaqi; Hardman 1983:42), Kawesqar (Alacalufan; Aguilera 2001:26), and Tehuelche (Chon; Garay 1998:84). The backing of /a/ to [ɑ] also occurs after uvulars in Ubykh (Rose 1996:98 citing Vogt 1963). A case of a more general backing process is found in the Mayan language Jacaltec, which exhibits backed allophones of /a, o, u/ before uvular consonants, retroflex consonants, and /w/ (Day 1973:12).

There are no clear examples of neutralizing backing. One possible case is in Coeur d'Alene regressive faucal retraction, in which /a/ is backed to [ɑ] and /$\text{i}_1$/ is also backed to [ɑ] (Bessell 1998b:128,132; see also §3.2.4.1).[12] This could, however, be viewed as a case of general neutralization, not just neutralization via backing. Another possible example is the neutralization of /e/ to /o/ following underlying /$\text{q}^\text{w}$/ in Kashaya. However, because /i/ and /a/ also neutralize to /o/ following /$\text{q}^\text{w}$/, this is better interpreted as general neutralization rather than neutralization via backing.

In general, although the effects of post-velar consonants are frequently thought to be both backing and lowering, the much more common effect is lowering. Backing is not only less common,

[11] The acute accent marks stress. No examples of normal epenthesis with [ɛ] are given in the source, nor is an example of epenthesis before /r/ given. The phoneme /r/ in Homshetsma, a western dialect, does not contrast with another rhotic phoneme.

[12] /$\text{i}_1$/ is from Proto-Interior Salish */i/ while /$\text{i}_2$/ is from */a/ outside of the environment of faucals (Bessell 1998b:132).

but frequently conditioned by uvulars as opposed to pharyngeals. As will be shown in the next section, pharyngeals can even cause fronting.

### 3.1.4 Vowel Fronting and Palatalization

Less well-noted in the literature is the fact that pharyngeals can cause vowels to front. This occurs for the low vowel /a/ in Egyptian Arabic and for both of Kabardian's two vowels. However, it also occurs regularly in several Northeast Caucasian languages, most likely as the result of a unique articulation for pharyngeals called "double bunching." Although it is commonly thought that pharyngeals cause backing effects, backing in the context of pharyngeals is quite rare (but is much more common with uvulars or post-velars as a phonological class). Pharyngeals most commonly lower vowels. Phonologically, then, the fronting of /a/ triggered by pharyngeals can be seen as the correlate of the more common lowering process that applies when the vowel is already [+low] and further lowering is impossible.

In Egyptian Arabic, the default realization of /a/ is [ɐ], but "[a]djacent to pharyngeals, ... /a/ is realized as [a] ... and /aː/ is optionally lowered to [aː]" (Watson 2002:272). That is, the phoneme /a/ is realized as fronted and slightly lowered when short, and optionally so when long.

(30) Fronting of /a/ from default [ɐ] to [a] next to pharyngeals in Cairene Arabic (Watson 2002:272)
  a. /ħadd/ → [ħadd] 'someone'
     /balaħ/ → [bɐlaħ] 'dates'
  b. /ʕamal/ → [ʕamɐl] 'he did'
     /saːʕa/ → [sɐːʕa]∼[saːʕa] 'hour'

This contrasts with its realization "[i]n the same phonological word as a pharyngealized [emphatic] coronal or in the adjacency of /q/, [where] /a/ is realized as [ɑ] ... and /aː/ as [ɑː]" (ibid.). This means that the low vowel /a/ is realized as fronted adjacent to pharyngeals, but as backed adjacent to uvulars or in the domain of Arabic's process of emphasis (uvularization) spread.[13]

(31) Backing of /a(ː)/ from default [ɐ(ː)] to [ɑ(ː)] in the domain of emphasis or in contact with /q/ (Watson 2002:272)
  a. /qatal/ → [qɑtɐl] 'he killed' (*[qɑtɑl])
     /tˤalab/ → [tˤɑlɑb] 'he demanded'
  b. /qaːm/ → [qɑːm] 'he got up'
     /ballaːsˤ/ → [bɑllɑːsˤ] 'earthenware jar'

In Kabardian, both phonemic vowels after pharyngeals seem to be fronted, with /a/ becoming [æ] and /ə/ becoming [ɛ] (Colarusso 1992:31).

(32) Realization of Kabardian /a/ and /ə/ when tautosyllabic with a pharyngeal consonant (Colarusso 1989:278)

[13] Recall that emphasis is marked with a superscript /ʕ/, as is conventional in linguistics, where the phenomenon of emphasis spread is connected to pharyngealization harmony.

a. /də-ħa-n/
[dəˤħħæˤn]
opening-enter-INT
"to enter (as into a door)" or "to call upon someone"

b. /da-ħə-n/
[daˤħħɛˤn]
with-carry.out-INT
"to carry something out with someone's help"

This is the only case found in this study in which all vowels are categorically fronted in contact with pharyngeals. The fact that Kabardian has only two underlying vowels (/a/ and /ə/) under the analysis of Colarusso (1992) may be the reason that it is the only language in this survey to exhibit categorical fronting in contact with pharyngeals. The vowel /ə/ cannot lower since the basis of its phonemic opposition with /a/ is height, and /a/ cannot lower since it is already low.

Vowel fronting that is triggered by pharyngeal consonants can affect not only /a/, but all back vowels. While the fronting of /a/ can be thought of as the result of the inability of a more general process of phonological lowering to apply, the more general fronting of back vowels in the context of pharyngeals is the result of the pharyngeals being produced via the "double bunching" articulation described in Moisik (2013:482-500). The "double bunching" articulation involves constriction of the epilarynx, but is otherwise very similar to the bunched articulation of American English /ɹ/ in that there is a posterior constriction that retracts the tongue toward the pharyngeal wall along with an anterior constriction that raises the tongue toward the hard palate. Thus, the production of pharyngeals via the "double bunching" articulation involves a constriction in the palatal region, and this explains how a more general fronting effect can occur with pharyngeals. The "double bunching" articulation of pharyngeals appears to be cross-linguistically rare, but is somewhat common in the Nakh-Daghestanian languages.[14] Several of these languages provide phonological evidence for the phonetic link between pharyngeal and palatal articulations.

Several Nakh-Daghestanian (Northeast Caucasian) languages show vowel fronting adjacent to pharyngeal or pharyngealized consonants. In Avar, Charachidzé (1981:17) writes that "in the immediate vicinity of the voiced and voiceless pharyngeal fricatives (/ʕ/ and /ħ/), ... the round vowels *o* and *u* are realized, respectively, as *ö* [ø; JCS] and *ü* [y; JCS]."[15]

(33) Fronting of /o/ and /u/ in Avar adjacent to pharyngeal consonants (Charachidzé 1981:17)

| | | |
|---|---|---|
| /goħ/ | [gøħ] | 'mountain' |
| /ħor/ | [ħør] | 'lake' |
| /ħúndul/ | [ħýndul] | 'testicles' |

[14]The effect of this articulation on neighboring sounds was noticed by Trubetzkoy (1931), who aptly called the effect "emphatic palatalization" (*emphatische-mouillierung*).

[15]No examples are provided in narrow phonetic transcription with these vowels next to /ʕ/, but words with such a structure exist, e.g. /ʕus/ 'tooth,' /ʕos-ól/ 'tooth (GEN)' (Charachidzé 1981:19).

In Kryz, "… [y] is an allophone of /u/ in certain words after a pharyngealized glottal or the preverb *ʁi-*" (Authier 2009:21).[16]

(34) Fronting of /u/ to [y] after pharyngeals in Kryz (Authier 2009:21)

| | | |
|---|---|---|
| /ʕul/ | [ʕyl] | 'eye' |
| /hut'id͡ʒ/ | [ħyt'id͡ʒ] | 'to hunt' |

However, "[i]f the following consonant is /z/ or /r/ the palatalization of /u/ into [y] is not produced" (ibid.)

(35) Blocking by /z/ or /r/ of fronting of /u/ to [y] adjacent to pharyngeals or preverb *ʁi-* in Kryz (Authier 2009:21)

| | | |
|---|---|---|
| /ʕiran/ | [ʕiran] | 'before' |
| /ʕuzurd/ | [ʕuzurd] | 'he is tired' |
| /ʁuz/ | [ʁuz] | 'Arise! Get up!' |

Finally, in Agul, "[u]nder the influence of a pharyngealized consonant, the following vowel undergoes pharyngealization—the vowel /a/ can change to /e/: *a→ä→e*, *u→u̇/ö* [ø; JCS]" (Magometov 1970:29).[17] These vocalic changes can signal the historical loss of pharyngealization, as in *qˤ'al [qˤ'æl]* > /q'el/ 'salt' (ibid.).

The same historical change, of **a* > /e/ occurring together with the loss of pharyngealization, occurred in "East Cushitic languages of the Omo-Tana group" (Hayward and Hayward 1989:187). This can be seen by comparing forms from Arbore, an Omo-Tana East Cushitic language, and Qafar, a non-Omo-Tana East Cushitic language.

(36) Historical vowel fronting conditioned by former pharyngealization (Hayward and Hayward 1989:187)

| *Proto Form* | *Arbore* | *Qafar* | |
|---|---|---|---|
| **saʕ* | seʔ | saʕ-a | 'cow' |
| **laħ* | leh | laħ | 'small stock animal' |

In Akkadian, an identical vowel change occurred (**a* > /e/), but the consonant was lost entirely, for example in **ʕaprum* > /eprum/ 'dust' and, with compensatory lengthening, in **baʕlu* > /beːlu/ 'lord' (ibid.).

Further phonological evidence for the articulatory connection between pharyngeal(ized) phonemes and palatal(ized) phonemes can be found in Lak and Tsakhur. Lak has phonemically contrastive pharyngealized variants of its three vowels (/a, i, u/). The back pharyngealized vowels, "/aˤ/ and /uˤ/ are pronounced by all speakers with a fronted articulation" such that they are realized as /æˤ/ and /œˤ/ (Anderson 1997:974). In this respect, Lak patterns with Avar, Kryz, and

[16] The same source describes /h/ as having both [h] and [ħ] as free variants.

[17] These changes are definitely meant to have applied diachronically, but it is unclear whether they are meant to apply synchronically as well. The likely interpretation is that they occur in the language whenever consonantal pharyngealization is present, whether that is at a prior stage of the standard language or in dialects that retain pharyngealization.

Agul. However, in Lak, pharyngealized vowels are also able to palatalize velar consonants and /l/ that occur in the same word (ibid.).[18]

Tsakhur also has phonemically contrastive pharyngealized vowels (Ibragimov 1990:19-23). These form minimal pairs with their plain counterparts (e.g. *abɨn* 'being located inside' vs. *aˤbɨn* '(male) cat'; 21), but also function as allophonic variants of the plain vowels in the environment of both pharyngealized consonants (e.g. *waˤqˤ'aˤ* 'sheep') and consonants with a primary or secondary palatal/post-alveolar articulation (21-22).

(37) Pharyngealized vowels conditioned by palatal(ized) consonants in Tsakhur (Ibragimov 1990:22)

a. From underlying /a/
t͡ʃ'aˤr 'hair'
maˤgʲ 'fringe'
waˤʃ 'hundred'

b. From underlying /ɨ/
bɨˤtʲ 'tail'
pɨˤlʲt' 'a comb'

c. From underlying /u/
uˤlʲd͡ʒuˤm 'week'
t͡ʃ'uˤmkʲ 'a whip'

While the association between pharyngeals and fronting in the Nakh-Daghestanian languages can be attributed to the prevalence of the "double bunching" articulation, the reason for fronting in languages like Egyptian Arabic and Kabardian is less clear. It is possible that the phonetic explanation is similar in that an epilaryngeal constriction, even with accompanying retraction of the tongue root, frees the rest of the tongue to form an anterior constriction. This is an area for future phonetic and phonological investigation.

### 3.1.5 Vocalic Offglides from Pharyngeal/Epiglottal Consonants

Post-velar consonants can produce effects on adjacent vowels that do not involve altering their quality. For example, some languages have perceptible vocalic transitions into or out of pharyngeal/epiglottal consonants. In Nuuchahnulth (Wakashan), "for many speakers, there can be a pharyngealized schwa transition between close vowels and a pharyngeal" (Carlson et al. 2001:277).

[18] Anderson (1997:974) writes that "[p]haryngealization is considered an auto segment in Lak (Kibrik and Kodzasov 1990), and may spread across most segments in the word, e.g. jaˤħuˤ 'bravery' or aˤrˤaˤbˤaˤ 'cart."' He notes that "Bouda (1949:9) lists forms that vary as to the realization of pharyngealization on the various vowels in the word, e.g. jaˤt'ul ∼ jat'uˤl ∼ jaˤt'uˤl 'red."' In cases where pharyngealization does not spread through the whole word and the velar consonant and/or /l/ occurs in the non-pharyngealized part of the word, it is unclear whether the consonant would be palatalized.

(38) Pharyngealized schwa offglides in Nuuchahnulth (Carlson et al. 2001:277)
/ʕiːħ/ → [ʕiːᵊħ] 'big'
/ʕiniːt͡ɬ/ → [ʡˤrᵊniːt͡ɬ] 'dog'[19]

A similar process occurs in Cairene Arabic, where long, non-low vowels in contact with a pharyngeal consonant are not lowered, but have a "lowered off-glide" between them and the pharyngeal (Watson 2002:278 citing Harrell 1957:46-48).

(39) Lowered off-glide after a pharyngeal onset (Watson 2002:278 citing Harrell 1957:46-48)
/waħiːd/ → [waħᵃiːd] 'Wahid (name); alone'
/rajħiːn/ → [rajħᵃiːn] 'going (masc. pl.)'

(40) Lowered off-glide before a pharyngeal coda (Watson 2002:278 citing Harrell 1957:46-48)
/beːʕ/ → [beːᵃʕ] 'sale'
/loːħ/ → [loːᵃħ] 'board'
/mamnuːʕ/ → [mamnuːᵃʕ] 'forbidden'
/mabħuːħ/ → [mabħuːᵃħ] 'hoarse'

The final example seems to indicate that the effect of a coda pharyngeal is stronger than the effect of an onset pharyngeal.

The offglides from pharyngeal/epiglottal consonants are low and central. The centrality can be accounted for by the fact that the offglide is a highly reduced vowel. However, the lowness of the offglide is likely related to the articulation of the pharyngeal.

### 3.1.6 Laryngealization or Creakiness

Pharyngeal/epiglottal consonants can also cause laryngealization or creakiness to occur on adjacent vowels. In Nuuchahnulth, "laryngealization can … occur on vowels preceding and following pharyngeals, and adjacent to ejective stops and affricates as in /ʔat'a/ [ʔʌ̰t'ʌ̰] 'thick"' (Carlson et al. 2001:277).[20] This laryngealization has the potential to spread non-locally. Carlson et al. (2001) remark that "[w]ords with multiple pharyngeals often have a constricted quality spreading across the entire form" (277). This shows that two articulatorily distinctive non-local effects can arise from pharyngeal/epiglottal consonants: The suite of effects described as post-velar harmonies and the spreading of laryngealization.

Local laryngealization caused by a pharyngeal/epiglottal consonant is also reported in Achumawi (Palainihan; California). In Achumawi, the voiceless epiglottal fricative /ʜ/ "is associated with laryngealized onsets of following vocoids and voiced continuants" as well as with glottalized continuants "in adjacent syllables" (Nevin 1998:66).

[19]It is puzzling that in this example, the schwa offglide is not transcribed as being between the pharyngeal/epiglottal and the vowel.

[20]The languages' two pharyngeal/epiglottal consonants /ħ/ and /ʕ/ descend from /χ, χʷ/ and /q', qʷ'/, respectively (Jacobsen 1969). It is thus possible to view laryngealization of an adjacent vowel as a possible holdover effect in the case of /ʕ/, but this interpretation is not available for /ħ/.

### 3.1.7 Pitch (F0) Effects

The voiced uvular phonemes /ɢ/ and /ɴ/ in Kusunda (isolate) are realized as the voiced pharyngeal fricative [ʕ], with preceding nasalization in the case of the latter phoneme (Watters 2005:377). However, these phonemes also cause lower pitch on the preceding vowel, as in the examples in (41).

(41) Lower pitch (F0) on vowels preceding phonetic pharyngeals in Kusunda (isolate; Watters 2005:377)

a. /ɲ-aɢ-an/
[ɲ-aʕ-an]
2S-go:IRR-IND
'You will go.'

b. /ɲ-aɴ-an/
[ɲ-ãʕ-an]
2S-sit-IND
'You sat.'

In these examples, the /a/ vowel after /ɲ/ and before /ʕ/ has had its pitch (F0) lowered by the pharyngeal [ʕ]. This indicates that the loss of pharyngeals may lead to low tone in diachronic tonogenesis since, synchronically, they cause effects that are like those caused by voiced stops and /h/ that have been lost (Hombert 1984).

## 3.2 Post-Velar Harmonies

Post-velar harmony processes are neither consonant nor vowel harmony, but consonant-vowel (CV) harmony systems. In this respect, post-velar harmony systems are similar to nasal harmony systems. Like nasal harmony systems, post-velarization can spread in some languages across an entire word or can be heavily restricted by phonological and morphological factors. Post-velarization can take the phonetic form of either uvularization (as in Arabic) or pharyngealization (as in Nakh-Daghestanian languages).

The best-known process of post-velar harmony is emphasis spread in Arabic in which "emphasis" (uvularization) can spread to other phonemes at a distance, sometimes even across word boundaries. Azerbaijani Jewish Aramaic is another Semitic language that has emphasis harmony (Hoberman 1985, 1988). Outside of the Semitic stock, Berber languages have processes of emphasis spreading that are very similar to those in Arabic (Boukous 2009), and some Interior Salish languages have harmony processes in which retraction is a feature that spreads on vowels and may affect consonants (Bessell 1998a). Finally, in Tsilhqot'in (Athabaskan), pharyngealization can spread non-locally, with processes targeting both vowels and consonants (Hansson 2007).

For each of these languages, this survey describes the phonological triggers and targets, the phonetic changes caused by the process(es) on targets, the domain of application of the process(es), and which kinds of segments act as transparent or opaque in each process. First, Azerbaijani Jewish

Aramaic (AzJA) is presented to illustrate a clear case of post-velar harmony with a large domain (§3.2.1). Arabic is presented next (in §3.2.2) because the domain of its process of emphasis harmony is more restricted than that of Azerbaijani Jewish Aramaic. Berber is then presented in §3.2.3 to show a case of emphasis spread that is very similar to that of Arabic, but with a domain that can be defined largely without reference to morphology. Looking to the Americas, the post-velar harmonies of the Interior Salish languages are presented in §3.2.4 before continuing on to Tsilhqot'in (Chilcotin; Athabaskan) in §3.2.4. Both the Interior Salish languages and Tsilhqot'in show striking parallels with Arabic. After this, processes of pharyngealization harmony in Nakh-Daghestanian (Northeast Caucasian) languages are presented starting with strictly phonological harmony systems in Rutul (§3.2.6) and Archi (§3.2.7), and concluding with a heavily morphologically-restricted process in Icari Dargwa (§3.2.8).

### 3.2.1 Azerbaijani Jewish Aramaic (Semitic) Emphasis Harmony

In Azerbaijani Jewish Aramaic, the trigger of emphasis is a feature ([+constricted pharynx] in the source) associated with a syllable. The formal target of emphasis is the syllable, and any segment (consonant or vowel) can be realized as emphatic.

Both consonants and vowels "are more or less pharyngealized," among other specific effects for certain segments (Hoberman 1988:23-24, citing Garbell 1965:33). Among the consonants, labials have additional lip protrusion and rounding, /r/ is realized as a trill rather than a tap, and /p, t, k/ are realized with laryngealization (23).[21] Among the vowels, /i/ and /a/ are backed to /ɨ/, /ɯ/ and /ɑ/, /ɒ/, respectively (23-24). The post-velar segments, /q/ and /h/, are the "least affected" by emphasis (24, citing Garbell 1964:88).

The domain of emphasis harmony in AzJA is the entire word. "In the great majority of cases, a whole word – including the stem, prefixes, and suffixes – is either emphatic or plain" (Hoberman 1988:4). However, "a small minority [of stems] (2%) are mixed, having a plain part followed by an emphatic part" (ibid). Only one of these mixed stems has an emphatic syllable followed by a plain syllable (ỵạṣmin 'jasmine'; 7), the rest have one or more plain syllables followed by one or more emphatic syllables (5).

(42) Mixed plain and emphatic words in AzJA (emphasis indicated by underlining; Hoberman 1988:5,7)
ʃaraw 'corn growing of its own accord'
riswaj 'unmannerly speech'
sawsar 'mole'
sejfullah 'a great deal'
fandbaz 'trickster'
peʃtamal 'towel'

[21] These effects are all consistent with others found in the literature. Watson (2002:269-270) reports lip-rounding as an enhancement effect on emphatic consonants. Recasens and Pallarès (1999) report a stronger posterior constriction with trilled /r/ than the tap /ɾ/, and laryngealization is reported with pharyngeal consonants in Nuuchahnulth and Achumawi, as shown in §3.1.6.

This is taken as evidence that while emphasis is usually a floating level feature that associates with an entire phonological word, a syllable can be specified as emphatic and then that emphasis can spread rightward in the case of mixed stems (5-6). This is supported by the behavior of certain derivational suffixes, which always surface as emphatic and do not cause their base to become emphatic (11-12). That analysis is also supported by the fact that the only three prefixes in the language are underlyingly neutral and are made emphatic only when the whole word to which they attach is emphatic (13-14).

(43) Neutral prefix *na-* 'not, un-' assimilating to word-level emphasis (Hoberman 1988:14)

a. xoʃ 'good, pleasant' → **na**xoʃ 'ill, sick'

b. razi 'satisfied' → **na**razi 'unsatisfied' (***na**razi)

No segments are transparent to emphasis harmony nor are any segments opaque to it in AzJA (3-4).

### 3.2.2 Cairene and San'ani Arabic Emphasis Spread

The process of emphasis spread in Arabic is the non-local spreading of emphasis (uvularization) from uvular consonants and underlyingly emphatic consonants.[22] In the colloquial Arabic varieties of Cairo (Egypt) and San'a (Yemen), the triggers of emphasis spread are the primary emphatics /t$^{ʕ}$, d$^{ʕ}$, s$^{ʕ}$, z$^{ʕ}$/ and the secondary emphatics /r$^{ʕ}$, l$^{ʕ}$, m$^{ʕ}$, b$^{ʕ}$/ (Watson 2002:273-275). All phonemes are potential targets of emphasis spread.

The emphatic consonants are articulated with a secondary uvular articulation. Watson (2002:269) notes that the eighth century Arab grammarian Sibawayh claimed that "emphasis involved raising the tongue dorsum towards [. . . ] 'the upper palate,' a place said to lie between the points of articulation for /k/ and /ħ/." Later articulatory research showed that the articulation for emphasis takes place in the upper pharynx, near the area at which uvulars are articulated (ibid.; Ghazeli 1977). This description seems particularly apt given that the effects of emphasis on vowels, which include backing, are in stronger agreement with the facts established in the previous sections for uvulars than for pharyngeals. It is for this reason that this study follows McCarthy (1994), Shahin (2002), and Watson (2002) in phonetically characterizing emphasis as uvularization. However, it is still marked with the diacritic for pharyngealization (e.g. C$^{ʕ}$) in order to emphasize its connection with other post-velar harmony systems and because there is no established diacritic convention for uvularization. Moreover, no language phonemically contrasts uvularization with pharyngealization.[23]

The local effect of pharyngeal consonants is to front /a/ (realized by default as [ɐ]) and to lower short /i/ and /u/ (Watson 2002:272,277-278).

(44) Lowering and fronting adjacent to pharyngeals in Cairene (Watson 2002:271-272)

a. /tiʕmil/ → [tɛʕmɪl] 'she does, makes'

[22] The local lowering effects of pharyngeals (Watson 2002:270-273,277) and laryngeals (Shahin 2002:94-95) on vowels that are discussed below are not considered to be part of emphasis spread for the purposes of this section.

[23] The only possible example is Ju|'hoansi, but this problem disappears under the widely accepted cluster analysis explained in §2.2.3.

b. /ħubb/ → [ħobb] 'love'
c. /ʕamal/ → [ʕamɐl] 'he did'

The lowering of short /i/ and /u/ is also attested next to laryngeals for Palestinian Arabic by Shahin (2002:94-95).

(45) Lowering of short high vowels adjacent to laryngeals in Palestinian Arabic (Shahin 2002: 94-95)
a. /suʔæːl/ → [sʊʔæːl] 'question'
b. /hibæ/ → [hɪbə] 'Hiba (female name)'

The effect of emphasis spread on vowels is different, however, with /i/ and /a/ being backed to [ɨ] and [ɑ], respectively, next to /q/ and the primary and secondary emphatics. In this same environment, /u/ is centralized to [ʉ] (Watson 2002:271-272).

(46) Centralization and backing adjacent to emphatics and /q/ (Watson 2002:271-272)
a. /tˤifl/ → [tˤɨfl] 'child'
/qidir/ → [qɨdɨr] 'fate'
b. /daqiːqa/ → [dɑqɨːqɑ] 'minute'
/ʃunatˤ/ → [ʃʉnɑtˤ] 'bags'
c. /dˤuhr/ → [dˤʉhr] 'noon'

The domain of emphasis spread in both Cairene and San'ani Arabic is affected by both phonological and morphological factors, and is significantly more restricted than in Azerbaijani Jewish Aramaic, even though its effects are often still wide ranging. The domain of emphasis spread from a primary emphatic is most commonly within the stem (274, 280-281). The spread of emphasis may be blocked by a non-tautosyllabic /i/ or /j/ to right of the underlying emphatic consonant (ibid.). However, non-tautosyllabic /i/ and /j/ never block the spreading of emphasis if they occur to the left of the underlying emphatic but within the stem (274). In the following examples, underlining indicates the domain of emphasis and only the underlying emphatic is marked as such (with 'ˤ').

(47) Blocking and non-blocking of emphasis spread by /i/ and /j/ (examples from Watson 2002:274,281; possible blocking segments in bold)
a. masˤa**ːji**b (blocking) ∼ masˤa**ːji**b (non-blocking) 'misfortunes' (Cairene)
b. tˤaw**iː**l (blocking) ∼ tˤaw**iː**l (non-blocking) 'long' (San'ani)
c. j**i**sˤiːħ 'he shouts' (Cairene)
d. m**i**statˤiːl 'long, elongated' (San'ani)

In both Cairene and San'ani, emphasis may spread into the preceding word when the emphasis originates on the word /ʔalˤlˤaː/ 'God' (274,280).

(48) Extension of emphasis spread from the word for 'God' (examples from Watson 2002:274, 280)

a. in ʃaː ʔalˤlˤaː ‘God willing’ (Cairene)
b. maː ʃaː ʔalˤlˤaːh ‘fantastic!’ (San‘ani)[24]

In Cairene, the leftmost rhyme in a word preceding a word with an underlying emphatic can be emphasized (274), but in San‘ani, the only part of a preceding word that can be made emphatic is a word-final stop that could syllabify with the following word or is in direct contact with a following underlying emphatic (280).

(49) Emphasis spread left of a separate word with an underlying emphatic (examples from Watson 2002:274,280)
a. liban dakarˤ ‘Frankincense resin’ (Cairene)
b. awgaːt aðˤ-ðˤuhr ‘around midday’ (San‘ani)
ʕiddat tˤurug ‘a number of ways’ (San‘ani)

The domain of emphasis spread from the secondary emphatics is limited to the phonological word and is always blocked by /i/ or /j/ (275).

(50) Blocking of emphasis spread from secondary emphatics by /i/ and /j/ (examples from Watson 2002:275; blockers in bold)
a. dirˤaːsa ‘learning’
rˤaːg**i**l ‘man’
b. rˤam**j**a ‘ash’ mˤa**jji**ti ‘my water’

The high front vowel /i/ and the palatal glide /j/ block the spread of emphasis in various ways. They block the spread of emphasis from a primary emphatic outside of the phonological word, and even within it if they are to the right of the underlying emphatic and outside its syllable. They categorically block the spread of emphasis from a secondary emphatic.

Even though Arabic emphasis spread is the best known example of non-local spreading of a post-velar articulation, the mechanics of the process are quite complex and vary depending on the trigger and on the phonological and morphological composition of the word. One kind of trigger, the secondary emphatics, spread emphasis only throughout a stem and this spread is blocked by /i/ and /j/. Another kind of trigger, the primary emphatics, spread emphasis at the greatest distance throughout a phonological word and in a few cases into the preceding word. This spreading process can be blocked by /i/ and /j/ in limited circumstances, but is generally not blocked within a phonological word. The emphasis spread triggered by the emphatics (and /q/) also has a qualitatively different effect on vowels, centralizing high vowels and backing the low vowel. Although Arabic is the canonical example of a language with post-velar harmony, its post-velar harmony system is certainly not the simplest to describe. In fact, it shows that while all its phonemes with a post-velar secondary articulation cause some effect on neighboring vowels, they all do so in different ways.

[24]This example is fully emphatic throughout in Cairene (Watson 2002:274).

### 3.2.3 Tashlhiyt Emphasis Spread

The triggers of emphasis spread in Tashlhiyt (Berber) are the underlying emphatic consonants /tˤ, dˤ, sˤ, zˤ, ʃˤ, ʒˤ, rˤ, lˤ/ and their geminate counterparts (Boukous 2009:390). All these consonants are articulated with retraction of the tongue root, and presumably the epiglottis as well, toward the posterior wall of the pharynx (387). While the emphatics /dˤ, tːˤ, zˤ, zːˤ/ are reconstructed for Proto-Berber (Kossmann 1999:249), the other emphatics in Tashlhiyt "are generally attested in borrowings from Arabic" (Boukous 2009:391). Emphasis spread targets all the segments within a prosodic domain that is influenced by speech rate (Boukous 2009:391-393).

The spread of emphasis is realized as pharyngealization, with consonants having secondary tongue root retraction (387). Vowels are realized with raised F1 and lowered F2, which translates to vowel lowering and backing (ibid.).

The domain of pharyngealization[25] spreading in Tashlhiyt is determined primarily by speech rate (391-394). In slow or careful speech, pharyngealization spreads only to the nucleus of its syllable. In normal speech, it spreads throughout the syllable of the underlying emphatic. In fast speech, it spreads throughout the entire prosodic word (ibid.).

(51) The domain of emphasis spread according to speech rate for the word /ta+dˤrdˤur+t/ 'deaf (fem.)' (Boukous 2009:393-394; emphasis indicated by underlining)

   a. Slow: ta.dr.durt
   b. Normal: ta.dr.durt
   c. Fast: ta.dr.durt

It is an open question whether or not the slow/careful emphasis spread is phonological or simply co-articulation. If CV (onset-nucleus) were shown to be a constituent below the syllable level and the nucleus was shown to be emphatic throughout, then emphasis spread at the slow/careful speech rate could reasonably be said to be phonological. The normal and fast speech domains are clearly phonological since they make reference to prosodic categories.

In Tashlhiyt, all segments are pharyngealized when they are in the domain of spreading, so no segments act as transparent or opaque.

The system of Tashlhiyt pharyngealization harmony appears to be entirely phonetic, in that it is driven by factors that explicitly affect speech articulation. However, the differences between the process at different rates of speech refer to phonological constituents.

### 3.2.4 Interior Salish

The Interior Salish languages possess processes of post-velar harmony that are similar to those found in Azerbaijani Jewish Aramaic, Arabic, and Tashlhiyt in that their effects can be wide ranging, but are restricted by both phonological and morphological factors.

[25] Because the primary correlate of emphasis in Tashlhiyt is pharyngealization, that more precise term is used instead of "emphasis" from here on.

#### 3.2.4.1 Regressive Faucal Retraction Harmony

Two Interior Salish languages, Coeur d'Alene (Snchitsu'umshtsn) and Spokane-Kalispel-Flathead (Bessell 1998b:127-128), have processes of long-distance regressive retraction harmony originating on a 'faucal' consonant to the right. In these languages, the uvulars and pharyngeals serve as triggers, as well as /r/ and /rˀ/ in Coeur d'Alene and retracted /ḷ/ and /ḷˀ/ in Kalispel.[26] These triggers comprise the 'faucals' in each language, and to form a natural class in these languages through their roles in these harmony processes. Phonetically, retracted vowels are generally lowered. The targets are /$i_1$, $i_2$, u, a/ in Coeur d'Alene and /e, u/ in Spokane and Kalispel.[27]

The phonetic effects of retraction can be shown in the table below, which is modeled after Table 3.1 and is adapted from Bessell (1998b:128).

| | / $i_1$ / | / $i_2$ / | / u / | / e / | / a / |
|---|---|---|---|---|---|
| Coeur d'Alene | ɑ | ɛ | ɔ | | ɑ |
| Kalispel | | | o | a | |
| Spokane | | | ɔ | a | |
| Flathead | | | ɔ | ɑ | |

Table 3.2: Effects of long distance regressive faucal retraction in Coeur d'Alene and Kalispel-Spokane-Flathead (adapted from Table 1 in Bessell 1998b:128 with data from Bessell 1998a:7)

Note from these effects that regressive faucal retraction harmony is neutralizing in Coeur d'Alene, collapsing the distinction between /$i_1$/ and /a/, which both surface as /ɑ/ when regressive faucal retraction harmony has applied.

The domain of regressive faucal retraction harmony is the entire word except for most prefixes (Bessell 1998a:6).

(52) Examples of words affected by regressive faucal retraction harmony in Coeur d'Alene (examples from Bessell 1998b:132)

a. /t͡s**i**ʃ=**a**lqʷ/
[t͡s**ɛ́**ʃ**ɑ**lqʷ]
be.long=long.stiff.object
'he is tall'

b. /t͡ʃ-dl**i**m=**a**lqʷ/
[t͡ʃdəl**ɑ́**m**ɑ**lqʷ]
attached.to-be.long=long.stiff.object
'train'

[26]The retracted consonants have a post-velar articulation, but its identity is not completely certain. They are generally characterized by low F2 (Bessell 1998b:141-142).

[27]The vowels /$i_1$/ and /$i_2$/ are from historical */i/ and */a/, respectively. */a/ shifted to /$i_2$/ except "in the context of faucals, where it surfaces as [ɑ]" (Bessell 1998b:132).

c. /ʔ**ɛ**t͡s-hin-t’**e**kʷ’=qin/
[ʔ**ɑ**nt’**ɑ́**kʷ’qən]
ASPECT-LOC-one.lies-head/top
‘it lies on top’

d. /ʔ**ɛ**t͡s-t-k**u**s=qin/
[ʔ**ɑ**tk**ɔ́**sqən]
ASPECT-on/part.of-be.curled-head/top
‘his hair is curled’

It is worth noting that /i/ is transparent in regressive faucal retraction harmony in Spokane-Kalispel-Flathead (Bessell 1998b:127-128). Instead of being antagonistic to the harmony process, as in other languages and in the process of progressive retraction harmony, /i/ simply does not participate in regressive faucal retraction harmony. No segments are opaque to the leftward progression of regressive faucal retraction harmony in any of the Interior Salish languages that have the process.

(53) Transparent /i/ in Flathead (examples from Bessell 1998a:7)

a. [q’**e**ʔʃín] ‘shoe’
[q’**a**ʔʃin-sqá(χeʔ)] ‘horseshoe’

### 3.2.4.2 Progressive Retraction Harmony

Progressive retraction harmony occurs in all the Interior Salish languages. The trigger of progressive retraction harmony is a retracting root. In that root, a retracted (generally mid or low) vowel occurs. This vowel is not transparently a transformation of some other vowel, so the retracted vowels that occur in retracted roots are simply listed for each language in the following table. The targets of progressive retraction harmony are the vowels of the suffixes following retracted roots. Some consonants are also the targets of retraction, but generally only within retracting roots. Here, as in Arabic, the domain of the retraction process is constrained by morphological factors. Also as in Arabic, the retracted consonants are a subset of the coronals, and, at least for /l/, lowered F2 is a primary correlate of retraction (Bessell 1998b:141-142).

| | Vs in R. Roots | Retr. Cs | / $i_1$ / | / $i_2$ / | / i / | / u / | / e / | / æ/ | / ə/ | / a / |
|---|---|---|---|---|---|---|---|---|---|---|
| Colville-Okanagan | /a/ | — | | | a | a | | | | a |
| Kalispel-Spokane | [a, o] | — | | | a | ɔ | a | | | |
| Coeur d’Alene | [ɛ, ɔ, ɑ] | — | ɛ / ɑ | | | ɔ | | | | |
| Shuswap | [ɛ, ɔ, a] | ṣ, t͡ṣ | | | ɛ | ɔ | ɑ | | | |
| Lillooet | [ɛ, ɔ, a, ʌ] | ṣ, t͡ṣ, ḷ, ḷˀ | | | ɛ | ɔ | | a | ʌ | |
| Thompson | | ṣ, t͡ṣ | | | | ɔ | a | | ʌ | |

| | | | | | | |
|---|---|---|---|---|---|---|
| Moses-Columbia | [ɛ, ɔ, ɑ, ʌ] | ṣ, t͡ṣ, ḷ, ḷˀ, (ṇ), (ɬ̣) | ɛ | ɔ | ʌ | ɑ |

Table 3.3: Effects of progressive faucal retraction on target vowels (adapted from Table 4 in Bessell 1998b:137; vowels in retracted roots as well as retracted consonants are shown)

(54) Effect of progressive retraction harmony on suffix vowels in Coeur d'Alene (examples from Bessell 1998b:137-138; underlyingly retracted root underlined, affected vowel bolded)

a. /t͡sɔʔt=i$_1$lmxʷ/
[ t͡s'ɔʔt**ɑ́**lˀəmxʷ ]
sob=person
'dwarf'

b. /t'Vp st͡ʃi$_2$nt/
[ t'ɑpst͡ʃ**ɛ́**nt ]
shoot people
'he shot (people)'

c. /tVm-n-t͡sut/
[ tɑmənt͡s**ɔ́**t ]
scorch-TRANS-REFL
'he scorched himself'

The domain of progressive retraction harmony is subsequent suffixes in a word when vowels are the targets. The domain for the retraction of consonants is uncertain, but includes at least (most of) the retracting root (Bessell 1998b:149).

The suffix consonants are transparent to the rightward progression of vowel retraction (presumably in all languages). However, the vowel /i/ acts as opaque to this rightward progression in the Thompson and Moses-Columbia languages.

### 3.2.5 Tsilhqot'in

The Athabaskan language Tsilhqot'in (Chilcotin) contrasts "sharp" consonants, which can be considered plain, with "flat" consonants, which are pharyngealized or retracted.[28] The only consonants that can be "flat" are the non-lateral coronal affricates and fricatives, /d͡z, t͡s, t͡s', s, z/, which form the "Ŝ-series," and the velars, which surface as uvular /q, qʷ, q', qʷ', ɢ, ɢʷ, χ, χʷ, ʁ, ʁʷ/ and form the "Q-series" (Hansson 2007:96).

[28]The term "flat" evokes the description of the phonetically-differentiating factor said to characterize post-velars in Jakobson et al. (1952) and used to describe Arabic emphatics and post-velars in Jakobson (1962).

| | Voiceless | Ejective | Voiced | Vcl. Fric. | Vcd. Fric. |
|---|---|---|---|---|---|
| *Sharp S-series* | ts | ts' | dz | s | z |
| *Flat Ŝ-series* | $ts^{ʕ}$ | $ts'^{ʕ}$ | $dz^{ʕ}$ | $s^{ʕ}$ | $z^{ʕ}$ |
| *Sharp K-series* | k, $k^{w}$ | k', $k^{w}$' | g, $g^{w}$ | $x^{w}$ | w |
| *Flat Q-series* | q, $q^{w}$ | q', $q^{w}$' | ɢ, $ɢ^{w}$ | χ, $χ^{w}$ | ʁ, $ʁ^{w}$ |

Table 3.4: Sharp (plain) vs. flat (pharyngealized) consonant series in Tsilhqot'in (Hansson 2007:96)

Perceptually, the "flat" Ŝ-series consonants are said to be very difficult to tell apart from their sharp counterparts, with their effects being heard primarily on neighboring vowels (Hansson 2007:98). The flat velars are primarily distinguished from sharp velars not through a decidedly uvular place of articulation, as the transcription suggests, but by having an affricated release (96-97). This is not at all unusual for Athabaskan languages, which frequently contain phonetically affricated dorsal consonants. Moreover, in many Nakh-Daghestanian languages, the uvulars are also realized as affricates. Although Hansson (2007:97-98) defends the description of these consonants as phonetically pharyngealized, the effects on vowels of these consonants (shown in Table 3.5) and the fact that the Q-series is affricated point to the quality of "flatness" being uvularization, similar to Arabic emphasis. Because the author cannot confirm that this is the case, this study follows Hansson (2007) in describing the "flat" consonants as pharyngealized and transcribes them as such (i.e. as $C^{ʕ}$).

The flat consonants affect adjacent vowels primarily by lowering them. These effects are summarized in the table below, taken from Hansson (2007:99).

| *Tense* | | | *Lax* | | |
|---|---|---|---|---|---|
| /i/ | → | [əi]∼[e] | /ɪ/ | → | [əɪ] |
| /u/ | → | [o] | /ʊ/ | → | [ɔ] |
| /æ/ | → | [a] | /ɛ/ | → | [ʌ] |

Table 3.5: Effects of flat consonants on adjacent vowels (Hansson 2007:99)

Tsilhqot'in has four separate processes of pharyngealization spreading, called "flattening," in which a pharyngealized consonant causes a nearby vowel to "flatten." In each process, when a vowel is "flattened," it is changed in the way indicated in Table 3.5 and is marked in bold. The differences between the four processes are primarily differences in directionality and domain. These processes interact with a process of consonant harmony called sibilant pharyngealization agreement in which all underlying S- or Ŝ-series phonemes in a word agree in terms of pharyngealization with the rightmost S- or Ŝ-series consonant.

#### 3.2.5.1 Progressive Ŝ-flattening

In progressive Ŝ-flattening, the trigger is a pharyngealized Ŝ-series consonant, and the target is a vowel immediately to the right of the segment. The domain of the process depends on whether the vowel is tense or lax. If it is tense, the flattening process goes no further than the immediately proceeding vowel. However, if it is a lax vowel, the flattening progresses to the next syllable to the right. This further progression of flattening from a lax vowel can be blocked by a plain velar (K-series; Hansson 2007:99-100).

(55) Progressive Ŝ-flattening (Hansson 2007:100; affected segments bolded)

a. Normal application with a lax vowel
/sˤ**ɛ**-i-tæn/ → [sˤ**əi**tæn] ‘I placed it (long object)’[29]
/tɛ-sˤ**ɛ**-tæn/ → [tʌsˤ**ʌ**t**a**n] ‘long object is on surface’

b. Blocking by a plain velar (K-series, underlined)
/sˤ**ɛ**-g**ɛ**n/ → [sˤ**ʌ**g̲ɛn] ‘it’s dry’ (*[sˤ**ʌ**g̲**ʌ**n])

#### 3.2.5.2 Regressive Ŝ-flattening

The targets and triggers of regressive Ŝ-flattening are the same as in progressive Ŝ-flattening. However, the domain is throughout the entire word preceding the segment, i.e. the process is unbounded to the left. Moreover, no consonants, even plain velars (K-series), act as opaque (Hansson 2007:100).

(56) Regressive Ŝ-flattening (Hansson 2007:100)

a. Normal application
/j**ɛ**-t**ɛ**-ʁ**ɛ**-ɬ-t͡sˤ**ʊ**sˤ/ → [j**ʌ**t**a**ɬt͡ʃˤ**ɔ**sˤ] ‘he’ll take it (cloth)’

b. Non-blocking by a plain velar
/gʷ**ɛ**-t**ɛ**-gʷɛ-i-l-juzˤ/ → [gʷ**ʌ**t**ʌ**g**o**lj**o**zˤ] ‘he is rich’

#### 3.2.5.3 Progressive Q-flattening

In progressive Q-flattening, the trigger is a Q-series phoneme, i.e. a uvular consonant, and the target is a nearby vowel. Unlike progressive Ŝ-flattening, the domain of the process is limited to the adjacent following vowel and cannot extend further, even if the adjacent following vowel is lax (Hansson 2007:100). Also in contrast to progressive Ŝ-flattening, all segments act as transparent. None act as opaque since the sharp K-series consonants, which could potentially act as opaque, are not able to occur in a blocking position for purely lexical and morphological reasons (101).[30]

(57) Progressive Q-flattening (Hansson 2007:100)

[29] Presumably, there is an intermediate form [sˤ**ʌ**-**əi**-tæn] that gets simplified to the surface form shown in this example.

[30] An experiment with nonce words that provide the necessary context would clarify whether all consonants are truly transparent to this process.

a. Normal application
/q**æ**nɪʃ/ → [q**a**nɪʃ] 'spoon'

b. Non-extension after a lax vowel
/ʁ**ɛ**-l-mɛɬ/ → [ʁ**ʌ**lmɛɬ] 'it's rolling' (*[ʁ**ʌ**lm**ʌ**ɬ])

#### 3.2.5.4 Regressive Q-flattening

Regressive Q-flattening has the same triggers and targets of progressive Q-flattening. The domain of flattening, however, extends only to the directly adjacent preceding vowel and no further (Hansson 2007:101). This is in contrast to regressive Ŝ-flattening, in which flattening proceeds all the way to the left word boundary. In addition, sharp series consonants act as opaque for this process and non-sharp Ŝ- and Q-series consonants are transparent.

(58) Regressive Q-flattening (Hansson 2007:101)

a. Normal application to a single vowel across a non-sharp series consonant
/dɛ-ʁɛ-**i**-l-q$^w$ɛs/ → [d**e**lq$^w$ʌs] 'I coughed'

b. Blocking by an sharp S-series sibilant
/nɛ(n)-tɛ-ʁɛ-s-ʁænɬ/ → [nɛnt**æ**sʁãɬ] 'I'll chase you' *[nɛntasʁãɬ]

#### 3.2.5.5 Sibilant Pharyngealization Agreement

In sibilant pharyngealization agreement, the rightmost instance of an S- or Ŝ-series phoneme determines whether all the preceding S- or Ŝ-series phonemes will surface as sharp S or flat Ŝ (Hansson 2007:102). The domain of the process is the word (ibid.). In this agreement process, post-alveolar affricates and fricatives (/t͡ʃ, t͡ʃ', d͡ʒ, ʃ/) are fully transparent (104). The process is only strongly attested when depharyngealization ("sharping") is the result. This is because the contrast between pharyngealized and plain non-lateral coronal affricates and fricatives can generally only be heard on the neighboring vowels, but the unbounded process of regressive Ŝ-flattening ensures that all vowels to the left of an Ŝ-series phoneme will surface as pharyngealized. This prevents a distinction between pharyngealized and plain vowels that would allow the contrast between an S- and Ŝ-series segment to be observed. The two examples below show the depharyngealization of /sˤ/.

(59) Sibilant pharyngealization agreement (Hansson 2007:102-103)

a. /næ#**sˤ**ɛ-s-l-k'æz/ → [næ**s**ɛsk'æz] 'I'm stiff again'

b. /ɬæ jɛ-tɛ-**sˤ**ɛ-ʁɛ-id-jɛz/ → [ɬæ jɛtɛ**z**ʌʁad͡ʒɛz] 'we're not going to get the hiccups'[31]

#### 3.2.5.6 Summary of Tsilhqot'in Flattening Processes

Table 3.6 summarizes the domains, trigger consonants, target vowels, and opaque consonants for each flattening process described here for Tsilhqot'in.

[31] The reason for depharyngealized /sˤ/ surfacing as [z] instead of [s] is due to a separate process (Hansson 2007:103).

| *Process* | *Domain* | | | | *Opaque* |
|---|---|---|---|---|---|
| Progressive Ŝ-flattening | | Ŝ | $V_1$ | if $V_1$ is tense | Plain velar (K-series) |
| | | Ŝ | $V_1V_2$ | if $V_1$ is lax | |
| Regressive Ŝ-flattening | $V_n \ldots V_1$ | Ŝ | | | None |
| Progressive Q-flattening | | Q | $V_1$ | | None |
| Regressive Q-flattening | $V_1$ | Q | | | Any non-Ŝ/Q-series C |

Table 3.6: Summary of the domains and opaque phonemes for each harmony process in Tsilhqot'in

### 3.2.6 Rutul Pharyngealization Harmony

Rutul (Nakh-Daghestanian) exhibits a system of pharyngealization harmony in which pharyngealized uvulars can spread pharyngealization to a non-local uvular consonant bidirectionally in the same word. That is, uvulars in a word must agree in terms of pharyngealization. In addition to this long-distance consonant harmony process, pharyngealized uvulars and pharyngealized glottals spread pharyngealization locally to strictly adjacent vowels (Alekseev 1994b:217). Although this creates the impression of a CV harmony process, the existence of unaffected vowels, such as /e/ in 'type of edible plant,' shows that the processes are separate.

(60) Non-local spreading of pharyngealization to a uvular consonant (Alekseev 1994b:217,237)

a. Rightward (progressive, perseverative) spreading with AGENT suffix /-qan/
neχir 'herd of cattle' + -qan → neχir-qan 'cowherd'
χˤɨb 'flock of sheep' + -qan → /χˤaba-qˤan/ 'shepherd'
ruχˤ 'mill' + -qan → ruχˤu-qˤan 'miller'

b. Leftward (regressive, anticipatory) spreading
ɢ-ajχˤas → ɢˤajχˤas 'to annoint'
q-uɢˤus → qˤuɢˤus 'to go away'

(61) Local spreading of pharyngealization to an adjacent vowel from both uvulars and glottals (ibid.; Ibragimov 1978:28,30,32)

a. /raʁas/ → [raʁas] 'to drink'
/raʁˤas/ → [raˤʁˤaˤs] 'to ask for, request'
/qˤʷajed-qˤ'uʃ/ → [qˤʷaˤjed-qˤ'uˤʃ] 'type of edible plant'

b. t'uˤʔ 'rope'
ʔuˤb 'loop'
daˤʔwi 'war, conflict, argument'
ħaˤdaˤħ 'brain'
ħaˤjæg 'a pan'
ħaˤχˤaˤd 'a harrow'

Two words confirm that uvulars and glottals need not agree in pharyngealization.[32] The word *aħmaq'ad* in *aħmaq'ad zar* 'fool's money' (Alekseev 1994b:238) indicates that pharyngealization does not spread rightward from a "pharyngealized glottal" /ħ/ to a uvular since otherwise the form **aħmaqˤ'ad* would be expected. The word *naχˤmaʔ* 'all day' (Alekseev 1994b:232) indicates that pharyngealization does not spread rightward from a pharyngealized uvular to a glottal since otherwise the form **naχˤmaʢ* would be expected.

With pharyngealization spreading to an adjacent vowel, the form in (60b) is [qˤuˤɢˤuˤs] 'to go away' (attested as present tense [qˤuˤʁˤuˤre] 'goes away' in Ibragimov 1978:37). The prevalence of pharyngealization leads to the impression that it may be associated with a prosodic category higher than the segment, such as the syllable. Even if this is so, uvular consonants still must be referenced by the phonology since they must agree in terms of pharyngealization. As will be seen, pharyngealized uvulars have a special status in Archi.

### 3.2.7 Archi Pharyngealization Spreading

Pharyngealization in Archi appears to be a prosodic feature that spreads across contiguous syllables. Kibrik (1994:303) describes pharyngealization in Archi as being "a suprasegmental feature extending over a syllable or a sequence of syllables" except "[i]f pharyngealized uvulars are present, then pharyngealization is not so much a prosodic feature or a characteristic of the syllable … as a segmental property of the uvulars" (304). It is unclear whether pharyngealization extends from these uvulars to adjacent vowels, as in Rutul.

When pharyngealization is not associated with uvular consonants, it is realized as a suprasegmental prosodic feature that spreads depending on stress and morphological structure. The degree of pharyngealization is not equal on all the syllables to which it spreads. Instead, pharyngealization operates as one might expect a gesture in Articulatory Phonology (Browman and Goldstein 1986) to operate, with a target syllable exhibiting the greatest degree of pharyngealization with surrounding syllables, especially following syllables, exhibiting a lesser degree. Kibrik (1994:304) describes the system in the following way:

> If the first syllable is stressed and pharyngealized, then that syllable is highly pharyngealized, while the post-tonic syllables are moderately or weakly pharyngealized. In orthographic transcription, pharyngealization is notated only for the vowel of the first syllable: *ʃːáˤbi* 'wound,' *páˤtːəla* 'trousers'[33], *báˤk'on* 'string.' If the second syllable is stressed, then strong pharyngealization usually, but not always affects the first and second syllables, for example: *aˤngáˤ-bos* 'to weep,' *t͡ʃ'uˤbáˤtːut* 'white,' *oˤróˤs* 'Russian.'

[32]The only consonants that can be pharyngealized in Rutul are uvular and glottal consonants (Ibragimov 1978:22). It is assumed here for Rutul that the pharyngealized equivalents of glottal consonants are primary pharyngeals, i.e. /ʔˤ/ = [ʢ] and /hˤ/ = [ħ].

[33]If this is a loan from Russian *pantalóny*, then pharyngealization seems to be the adaptation of the nasal consonant in the first syllable.

This suggests that the first binary foot is the primary domain of pharyngealization, although it may bleed into following syllables. Kibrik (1994:304) also notes that morphological structure and certain segments may, at least to some extent, inhibit the spread of pharyngealization, stating that "[i]n a number of cases (depending on the morphological structure, segmental composition, or etymology), only one of the initial two syllables is strongly pharyngealized: *beʃéˤrʃir*, 'CONST. 3SG. it rots,' *hoˤló* 'to be liquid (of manure).' "

### 3.2.8 Morphologically-Restricted Vocalic Pharyngealization Harmony in Icari Dargwa

The Icari dialect of Dargwa (Nakh-Daghestanian) exhibits a system of pharyngealization harmony among vowels that is governed by both morphological and phonological restrictions. In Icari Dargwa, pharyngealization only occurs with back vowels, not with other vowels or consonants (although the language does contain the primary pharyngeal consonants /ħ/ and /ʕ/; Sumbatova and Mutalov 2003:2). Pharyngealization is phonemically contrastive, as shown by the minimal pairs /ʃam/ 'lamb' vs. /ʃaˤm/ 'candle' and /b=irqːuj/ 'dig (SBJV)' vs. /b=irqːuˤj/ 'soil (SBJV)' (ibid.).

The triggers of pharyngealization harmony are pharyngealizing verb stems and pharyngealizing affixes (Sumbatova and Mutalov 2003:4-5). Only a limited set of verb stems and affixes are pharyngealizing, and although these do show phonetic pharyngealization if they contain /a/ or /u/, they need not bear any phonetic pharyngealization to belong to be considered part of the pharyngealizing verb stems (e.g. /b=irq-/ 'chop,' which is classified as pharyngealizing; 5). The pharyngealizing verb stems all "end in a back consonant (velar, uvular, pharyngeal or glottal), but not all stems ending in these consonants belong to the pharyngealizing class" (ibid.).

The pharyngealizing affixes are those that contain the vowel /i/, which include: "the preterite marker -ib, the thematic element -i-, and the masdar suffix -ni" (ibid.). The front, high vowel /i/ can be antagonistic to the spread of a secondary post-velar articulation (e.g. emphasis in Cairene and San'ani Arabic; Watson 2002:274-275,281), so it is surprising that it is the element that all pharyngealizing affixes have in common in Icari Dargwa. One possible explanation is the loss of an overtly pharyngeal segment, e.g. /ʕ/, but another is the connection between pharyngealization and palatalization that can result from the "double bunching" articulation of pharyngeals (§3.1.4). If the "double bunching" articulation is used for Icari Dargwa pharyngealized vowels, for which there is some support from Gaprindašvili (1966), then the palatal articulation of /i/ may be the trigger for pharyngealization (cf. palatal consonants triggering pharyngealization on vowels in Tsakhur; §3.1.4).

The targets of pharyngealizing verb stems include only a limited set of suffixes, not all of the suffixes that could potentially bear pharyngealization by virtue of containing /a/ or /u/.[34] The set of suffixes that can be pharyngealized by a pharyngealizing stem are: the thematic elements *-u-*, *-ar-*, and *-an-*, the progressive stem marker *-a-*, the obligative stem marker *-an*, the imperative marker *-a-*, and the prohibitive prefix *ma-* (Sumbatova and Mutalov 2003:5).

[34]One such suffix which could bear pharyngealization due to its phonological structure, but in fact does not, is the suffix *-ur*. (64b) shows that pharyngealization can spread through the causative suffix.

(62) Pharyngealization spreading from a verb stem to an adjacent suffix that is capable of bearing pharyngealization (ibid.)

a. Spreading to the thematic elements *-u-*, *-ar-*, and *-an-*

i. r=irʕ-uˤ-j
CL=deceive-THM.EL-SBJV
'deceive (her; SBJV)'

ii. w=aˤħ-aˤr-aj
CL=go-THM.EL-SBJV
'go (SBJV)'

iii. b=aˤʕ-aˤn-aj
CL=wrestle-THM.EL-SBJV
'wrestle (SBJV)'

b. Spreading to the progressive stem marker *-a-*
iq-aˤ-tːa
chop-PROG-1.PRS
'(I) chop'

c. Spreading to the obligative stem marker *-an-*
t͡ʃipːiχː-aˤn-ni
leave-OBLIG-3.FUT
'(he) will leave'

d. Spreading to the imperative marker *-a*
xʷit'.d=aˤq-aˤ (xʷit'.d=aˤq- 'whistle')
whistle-IMP
'whistle!'

e. Spreading to the prohibitive prefix *ma-*
maˤ-ʕ-uˤ-tː
PROH-go-THM.EL-2
'don't go!'

The set of suffixes that can be pharyngealized is lexically or morphologically specified as are the set of verbs that can cause that pharyngealization. The only phonological restriction is one that holds for the phonemic inventory as a whole: Only the back vowels /a/ and /u/ can bear pharyngealization. Thus, the spread of pharyngealization from verb stems is governed almost entirely by morphology.

In contrast, the targets of pharyngealizing affixes are subject to a purely phonological restriction. The only verb stems that can be pharyngealized are those that "(1) contain /a/ or /u/ and (2) end in [a] uvular consonant or" a cluster consisting of /r/ or /l/ plus a uvular consonant (Sumbatova and Mutalov 2003:5). The causative suffix *-aq-*, which can intervene between a verb stem and a pharyngealizing suffix, undergoes pharyngealization itself while allowing pharyngealization to pass through it to the verb stem (ibid.). (64a) shows an example of the causative suffix taking pharyngealization while the verb stem is blocked from receiving it because it does not satisfy the phonological criterion of ending in a uvular consonant or a cluster or /r/ or /l/ followed by a uvular. (64b) shows spreading through the causative to a verb stem which does satisfy the phonological restriction.

(63) Pharyngealization spreading from a pharyngealizing affix to a verb stem (Sumbatova and Mutalov 2003:5)

a. b=aˤq'-ib < b=aq'- 'hear'
CL=hear-PRET
'heard (AOR)'

b. uˤχː-i-d < uχː- 'know'
know-THM.EL-1
'I (M) know (POTENTIAL PRESENT)'

c. b=aˤrʁ-ni < b=arʁ- 'collect'
CL=collect-MASDAR
'collect-MASDAR'

(64) Pharyngealization spreading from a pharyngealizing affix through the causative suffix *-aq-* (ibid.)

a. t͡ʃi.b=aʒ-aˤq-ib < t͡ʃi.b=aʒ- 'see'
see-CAUS-PRET
'showed (AIR)' (Note non-pharyngealization of the verb stem for phonological reasons)

b. b=aˤrʁ-aˤq-ib < b=arʁ- 'collect'
CL=collect-CAUS-PRET
'caused to collect (AOR)' (Verb stem is pharyngealized)

The domain of pharyngealization harmony is broadly the word, but pharyngealization spreads from triggers only to adjacent morphemes. The exception to this is the causative morpheme, which can receive pharyngealization, but allows it to continue passing through to an adjacent morpheme that is able to take pharyngealization.

Vocalic pharyngealization harmony in Icari Dargwa operates bi-directionally, with morpheme composition and identity determining the directionality. When spreading proceeds from stems to suffixes, harmony operates progressively, but when it goes from stems to the prohibitive prefix (*ma-*), it operates regressively. Likewise, harmony operates regressively when pharyngealization spreads from suffixes to stems.

### 3.2.9 Summary of the Surveyed Post-Velar Harmony Processes

The post-velar harmony processes surveyed here come from languages from unrelated stocks which are in some cases geographically very distant from each other, yet they boast some striking similarities. In Arabic, the Interior Salish languages, and Tsilhqot'in, the effects of primary uvular and pharyngeal consonants on vowels are strictly local while the effects of segments that are secondarily pharyngealized are able to spread to a greater distance. In all these languages, but to a lesser extent in Arabic, the extent of spread is greatest in the leftward (or right-to-left) direction. It is also interesting to note that in Arabic, Thompson, and Spokane-Kalispel-Flathead, the rightward progression of emphasis or retraction, respectively, can be blocked by /i/, but in these languages the progression of emphasis or retraction is not blocked in the leftward direction. This shows a bias toward right to left (i.e. anticipatory or regressive) directionality, which is consistent with the default directionality of consonant harmony (Hansson 2010:142-152). In addition, the secondarily pharyngealized consonants are a subset of the coronals in Arabic, some of the Interior Salish languages, and Tsilhqot'in. Arabic, the Interior Salish languages, and Tsilhqot'in cluster together in a meaningful way from the point of view of phonological typology.

AzJA and Tashlhiyt (Berber) also seem to cluster together. In both, every segment is a potential target for emphasis, even though only a subset of coronal consonants are considered to be underlyingly emphatic. However, the domain of application for emphasis spread seems to be almost strictly prosodic, rather than partly morphological, in both languages. Both languages exhibit entire words being made emphatic, and in both languages, processes appear to refer to syllables as well. Therefore, with respect to post-velar harmony systems, there appear to be two major types of languages: 1) Languages of the Arabic, Interior Salish, Tsilhqot'in type, and 2) Languages of the AzJA, Tashlhiyt type.

The Nakh-Daghestanian languages do not strictly pattern with either of these groups, although they share important characteristics with both. Like Arabic, Interior Salish, and Tsilhqot'in, pharyngealization harmony in the Nakh-Daghestanian languages are limited by phonological and morphological factors. Rutul shows long-distance consonant harmony among uvulars that co-exists with strictly local CV pharyngealization. This is similar to how Arabic shows both long-distance and local effects, but in Arabic, both effects are CV effects. As in Interior Salish Progressive Retraction Harmony, Icari Dargwa's pharyngealization harmony system is constrained by morphology. However, it is so heavily constrained by morphology that it may actually be better termed a morphological, rather than phonological, process. While the Nakh-Daghestanian languages share similarities with the other languages surveyed here, they do not fit into their types. Moreover, they do not necessarily cohere into another type. Even though the pharyngealized uvulars have a special status in Rutul and Archi, these are both Lezgic languages, which means that this status could be a property of the Lezgian branch, not a separate typological group.

## 3.3 Other Processes

Local effects on vowels and post-velar harmony systems are the sound patterns most commonly exhibited by post-velar consonants. However, post-velars are involved in other types of sound patterns, including co-occurrence restrictions (§3.3.1), so-called 'guttural transparency' (§3.3.2), post-velar degemination (§3.3.3), deletion in the final position of a prosodic constituent (§3.3.4), and positional contrast neutralization (§3.3.5).

### 3.3.1 Co-occurrence Restrictions

Co-occurrence restrictions are distributional patterns in which certain phonemes cannot occur together within a certain domain. These restrictions are taken as evidence for the similarity of phonemes, and are used to motivate natural classes.

The most famous case of a co-occurrence restriction related to post-velars is the avoidance of two non-identical post-velars in Arabic roots (McCarthy 1994:204). Because there is a general restriction against non-identical homorganic consonants co-occurring in Arabic roots, the avoidance of non-identical post-velars in roots in Arabic is taken as evidence of them being phonologically homorganic and constituting a natural class. The frequency of relevant consonant combinations in Arabic roots is presented in the table below.

| 2nd C ↓ / 1st C → | k, g | q | χ, ʁ | ħ, ʕ | h, ʔ |
|---|---|---|---|---|---|
| k, g | 1 | 0 | 1 | 29 | 24 |
| q | 0 | — | 0 | 22 | 6 |
| χ, ʁ | 2 | 1 | 0 | 2 | 0 |
| ħ, ʕ | 34 | 22 | 0 | 0 | 2 |
| h, ʔ | 25 | 6 | 3 | 2 | 2 |

Table 3.7: Frequency of velar and post-velar consonant combinations in Arabic roots (McCarthy 1994:204)

The co-occurrence of the uvular stop /q/ with pharyngeal and laryngeal consonants is indicated by shading. The numbers are surprisingly high, especially for combinations with pharyngeals. The counts for the other uvulars are as expected if the post-velar consonants comprise a single place.

The Interior Salish languages also exhibit co-occurrence restrictions in which consonants of the same place and manner of articulation cannot co-occur in the same root.[35] In roots of the shape $C_1VC_2(C_3)$, the consonants $C_1$ and $C_2$ or $C_2$ and $C_3$ cannot be identical in both place and manner. For the purposes of these restrictions, velars and uvulars are treated as possessing an identical place of articulation, pointing to their unity as dorsal consonants. "Pharyngeals do not participate [in these co-occurrence constraints] in the sense that as resonants they can co-occur with stops and fricatives of any place of articulation, including dorsals, although there is only ever one pharyngeal per root" (Bessell 1992:208). Bessell notes on the same page that there are no roots of the shape pharyngeal-vowel-dorsal, but that there are roots of the shape dorsal-vowel-pharyngeal.[36] Glottals pattern together as their own place of articulation, as do labials and coronals, so that glottals can co-occur "with stops at all places of articulation, including uvular" (ibid.).

[35] Bessell (1992:207, fn. 16) verifies that these restrictions hold true for Moses-Columbia, Coeur d'Alene, Spokane-Kalispel-Flathead, Thompson, and Colville-Okanagan.

[36] Pharyngeals generally do not occur in $C_3$ position, except in the root /x$^{w}$aj$^{ʔ}$ʕ/ 'scold' in Moses-Columbia (Bessell 1992:219). Glottals never occur in $C_3$ position (ibid.). This is an example of pharyngeals and glottals patterning together in Interior Salish.

Similar root co-occurrence restrictions occur in Ju|'hoansi. Miller-Ockhuizen (2003) divides both the consonants and vowels into guttural and non-guttural classes. The definition of guttural consonants for that work is quite different from the one used for Arabic. The guttural consonants of Ju|'hoansi are /χ, q͡χ', h/, clusters with /χ/ or /q͡χ'/ as their second member, and the aspirated and glottalized/ejective consonants (Miller-Ockhuizen 2003:16-20, following the reinterpretation of the Ju|'hoansi phonemic inventory by Nakagawa 2006:273-282).[37] The guttural vowels of Ju|'hoansi are the non-modal vowels, which include breathy, glottalized/creaky, and "epiglottalized" vowels (Miller-Ockhuizen 2003:67). Only /o/ and /a/ can be epiglottalized, and acoustically they are closer to the pharyngealized vowels of !Xóõ than to its strident vowels, which are described as being both pharyngealized and breathy (76). For the sake of cross-Khoisan comparability, the term pharyngealized is used here instead of epiglottalized.

The first co-occurrence restriction in Ju|'hoansi is a constraint against guttural consonants and guttural vowels occurring adjacent to each other in CV sequences in mono-morphemic roots (Miller-Ockhuizen 2003:140-143). The few exceptions to this constraint all involve an aspirated or glottalized/ejective consonant. However, after clusters with the uvular consonant phonemes /χ/ or /q͡χ'/ as the second member, non-modal vowels never occur. This points to non-modal vowels being disfavored after consonants with a marked release (aspiration or glottalization), but completely banned after a uvular consonant.[38]

| C1 ↓ / V1 → | Breathy | Glottalized/Creaky | Pharyngealized |
|---|---|---|---|
| Aspirated | 2 | 1 | 11 |
| Glottalized/Ejective | 0 | 2 | 0 |
| C+χ | 0 | 0 | 0 |
| C+q͡χ' | 0 | 0 | 0 |

Table 3.8: Co-occurrence of guttural consonants and guttural (non-modal) vowels (adapted from Miller-Ockhuizen 2003:142; counts are out of 1879 total CV sequences in mono-morphemic roots)

The second co-occurrence restriction in Ju|'hoansi is the Back Vowel Constraint, which Traill (1985:91) notes is "valid *mutatis mutandis* for all Khoisan languages, with very few exceptions." In Ju|'hoansi, the front vowels (/i/, /e/) cannot follow the apical clicks (post-alveolar /!/ and lateral /‖/) or the uvular consonants /x/ and /q͡χ'/ either alone or as the second members of clusters (Miller-

[37]The existence of the uvularized and epiglottalized consonants is a consequence of the analysis that Miller-Ockhuizen (2003) adopts, which is termed the *unit analysis* by Traill 1985:208-211, Güldemann 2001, Nakagawa 2006:250-272, Naumann Forthcoming:22-23. Following these researchers, the cluster analysis is adopted here, and under this analysis, Miller-Ockhuizen's uvularized consonants are interpreted as clusters of the form /Cχ/ and the epiglottalized consonants are analyzed as consonants in combination with ejective uvular affricates, taking the form /Cq͡χ'/. For a detailed comparison of Miller-Ockhuizen (2003)'s unit analysis to a cluster analysis, see Nakagawa (2006:273-282).

[38]It is unclear from the source whether /χ/ outside of clusters or the consonant /h/ are included in any of the counts provided in the table.

Ockhuizen 2003:154-158, Nakagawa 2006:231).[39] Miller-Ockhuizen (2003:157) writes that "[i]t is important to note that other guttural consonants, such as aspirated consonants and ejectives, co-occur with both back vowels and front vowels ... This observation provides evidence that laryngeals (e.g., aspirated and ejected consonants) are not specified for [pharyngeal] in Ju|'hoansi." This is yet another instance in which uvular consonants enforce a co-occurrence restriction more strongly in Ju|'hoansi.

Another variety of co-occurrence restriction is the ban against velar consonants co-occurring with uvular consonants in a word in some Turkic languages. The relevant Turkic languages (mainly Northeastern) have vowel harmony processes that cause words to surface either with only front vowels or only back vowels. In these languages, velar and uvular consonants are not phonemically contrastive, but surface according to vowel backness in the word. Velar consonants surface with front vowels while uvular consonants surface with back vowels. This is attested in the Northeastern Turkic languages Shor, Tuva, and Dolgan (see the inventory survey for references), as well as in Kolyma Yukaghir, an isolate (Maslova 2003a:35-37).

### 3.3.2 Guttural Transparency

Guttural transparency refers to processes in which vowels assimilate in quality to each other across an intervening post-velar consonant. The process is named after laryngeal transparency, an example of which is translaryngeal harmony in Kashaya (Pomoan). Within native lexical morphemes, the vowels in sequences such as /VʔV/ and /VhV/ must be identical so that forms like */aʔo/ are unattested (Buckley 1994:124-129).

(65) Examples of Laryngeal Transparency (as Translaryngeal Harmony) in Kashaya (Buckley 1994:125-126)

a. /s̓iʔi/ 'flesh'[40]
/mihilá/ 'west'

b. /tuʔúl/ 'old (of inanimates)'
/juhu/ 'pinole'

c. /neʔén/ 'like this, thus'
/behe/ 'bay nut'

d. /q'oʔo/ 'dance, song; sing'
/sohój/ 'a seal'

e. /qʰaʔa/ 'overnight'
/ʔaha/ 'mouth'

Guttural transparency is commonly applied to a phenomenon which is called "cross-guttural vowel assimilation" by McCarthy (1991:75-76), who identifies it in Geʿez† (Classical Ethiopic;

[39](Miller-Ockhuizen 2003:154) calls the apical clicks "back clicks" and calls the laminal clicks (dental /|/ and palatal /ǂ/) "front clicks."

[40]The phoneme /s̓/ is described only as glottalized in the source (Buckley 1994:12-14) and is therefore left in the same transcription here. The acute accent marks stress.

Semitic). The process "raises the short vowel *a* to its high counterpart *ɨ* when followed by a high vowel across a guttural," which includes the pharyngeals and glottals in Geʻez. In addition, "the short vowel *ɨ*" is lowered "to *a* when followed by *a* across a guttural" (76). McCarthy (1991:76) formalizes this process as shown below.[41]

(66) McCarthy (1991)'s formulation of guttural transparency in Geʻez (76)
$V \rightarrow [\alpha \text{ high}] \,/\, \underline{\quad} \, [\text{guttural}] \, [\alpha \text{ high}]$

The terms used to name this process are quite general, implying that all vowels must be identical in height across a post-velar, or that vowels are completely identical across post-velars. In fact, the process in Geʻez seems to be much more specific in that it primarily targets the low vowel /a/. Either /a/'s non-low counterpart, /ɨ/, lowers to /a/ (a case of full-identity assimilation), or /a/ is pulled up to its non-low equivalent by any high vowel. The specific properties of this process suggest that it is intimately related to the articulation of the post-velars themselves due to the connection between post-velars and vocalic lowness (and perhaps, by extension, to vowel height more generally). The formulation in (66) is quite possibly too general. This process does show, however, that at least certain characteristics of vowels are able to assimilate across post-velars, at least pharyngeals and glottals.

Ditidaht (Wakashan) shows a different process that might be identified as a form of guttural transparency. In Ditidaht, a process called "fusion" metathesizes vowels to create the combinations */ai/ and */au/, which are then simplified to the mid vowels /e/ and /o/, respectively. In the fusion process, the */ai/ and */au/ combinations may appear with /ʔ/ or /ʕ/ intervening between the two vowels without inhibiting the creation of mid vowels (Werle 2007:77).[42] Werle (2007:77) offers the following examples, which unfortunately do not contain an example of fusion across /ʕ/.

(67) Ditidaht vowel fusion (examples from Werle 2007:77)
  a. /hijuː=ʔat͡ɬ/ → [hijoːʔt͡ɬ] 'finished now'
  b. /huʔa-t͡sa-t͡ʃit͡ɬ/ → [hoʔt͡sat͡ʃt͡ɬ] 'go back'
  c. /p'ip'iʔ=ʔak=iːk/ → [p'ip'ʔeːʔkiːk] 'your ears'
  d. /RED-saːntiː-aːtχ/ → [saːsaːnteːtχ] 'Saturday'

In Pilagá (Guaicuru; the only language of South America with a pharyngeal/epiglottal consonant), the pharyngeal voiced fricative /ʕ/ occurs only in intervocalic position, surrounded by identical back vowels (either /a/ or /o/).[43] If guttural transparency is understood as a requirement that vowels be identical in some respect across a post-velar, especially /ʕ/, then the satisfaction of that requirement may have played a role in allowing /ʕ/ to arise in Pilagá.[44]

[41] I use a cover feature here, [guttural], to capture McCarthy's insight. This should not be taken as advocating a particular featural representation.

[42] /h/ does not seem to behave the same way as /ʔ/, and Ditidaht lacks /ħ/ except in borrowings from Nuuchahnulth.

[43] Although the pharyngeal consonant in Pilagá is most often surrounded by identical back vowels and Vidal (2001:46) claims that this is required, there are two forms which do not conform: /netaʕe/ 'he/she passes/ed by' and /loʕedaik/ 'tall' (ibid.:13). Both these forms are from the Pilagá de Navagán dialect, and in the Pilagá del Bañado dialect, the pharyngeal consonant in these words is instead realized as /g/, yielding /netage/ and /logedaik/.

[44] Pilagá /ʕ/ appears to have come from earlier */ʁ based both on comparing Pilagá's inventory with other Guaicuru languages and on the fact that /ʕ/ can be realized both as [ʕ] and as [ʁ] (Vidal 2001:30,38).

While the name of this process, '*guttural* transparency,' implies that all post-velars ('gutturals') can somehow act as transparent, guttural transparency phenomena seem to be a constellation of nuanced and conditional effects that point to explanations at lower articulatory levels. First, laryngeal transparency (or translaryngeal harmony) is well-attested as are processes in which vowels must be identical across pharyngeals in addition. The explanation for these processes is likely the same. The obligatory non-lingual articulations of laryngeal and pharyngeal consonants do not interfere with the articulation of vowels using the tongue dorsum and body. Guttural transparency (or transguttural harmony), understood as applying only to laryngeals and pharyngeals, is well-attested.

However, no language has full transparency across all post-velars, including uvulars. In languages in which uvulars participate, the transparency effects are limited in that only vowels which are especially compatible with dorsals by virtue of being round or back are likely to participate. In Iraqw (Cushitic), full transparency does not apply across uvulars (Rose 1996:77-78). Instead, structure preserving round vowel harmony occurs across dorsals, including both velars and uvulars, as shown in the data in 68 from Rose (1996:78).

(68) /hluuq-iim/ → [hluquum] 'kill a big animal or man (DURATIVE)'
/yukmáy/ → [yukumáy] 'lid of corn store'

In Iraqw, this is a separate process of dorsal rounding transparency in which /i/ and epenthetic vowels harmonize by assimilating to /u/ across velars and uvulars.

In Eastern Gitksan (Tsimshianic), laryngeal transparency applies fully, and evidence from description over approximately two decades (from ∼1986-2006) shows that laryngeal transparency was gradually extended to uvulars through specific paths that can be explained without recourse to the idea of an innate guttural natural class. Yamane-Tanaka (2006:141-144) summarizes the findings of Rigsby (1986), who shows that among older generations of Eastern Gitksan speakers, the language exhibits laryngeal transparency among all speakers as well as transparency across uvulars only for the rounded vowel /u/ (with allophones [u] and [ɔ]) for some speakers. Rigsby (1986:174) also noted that most speakers applied a gliding rule in which intervocalic /χ/ was consistently realized as /h/, feeding laryngeal transparency. However, some speakers did not apply the gliding rule, and yet realized the form as if laryngeal transparency had applied. This caused uvular /χ/ to become a transparent phoneme. Furthermore, younger speakers interviewed by Yamane-Tanaka had extended the domain of transparency of all uvulars to include not just the round vowel /u/, but the low vowel /a/. Some of these speakers have even extended the domain of uvular transparency to include the vowel /i/ (with allophones [i] and [ɛ]), have begun to include palatal/front velar /x/ as a transparent segment, and have ceased to apply transparency with /h/.

While formal phonology must be able to model these facts, their diachronic path of development is clear, and suggests that full guttural transparency, involving all post-velars, did not come about all at once, but arose through non-application of a formerly regular sound pattern (/χ/ → /h/ / V__V) and through the gradual extension of a process of dorsal transparency for the round vowel, which also occurs in Iraqw. Thus, 'guttural transparency' as a sound pattern in which vowels are identical across any kind of post-velar consonant does not appear to exist, and the systems that resemble it instead have two separate patterns of transparency, non-lingual transparency (across laryngeals and pharyngeals) and dorsal transparency (across uvulars and possibly velars), which have been analytically conflated.

### 3.3.3 Post-Velar Degemination

A number of processes that militate against post-velars may have their origins in the difficulty of perceiving post-velar consonants, especially in coda position. These processes include degemination, deletion (§3.3.4), and a neutralization of contrast (§3.3.5).

McCarthy (1994:216-217) shows that in Tiberian Hebrew and Tigré, where a geminate post-velar would be expected, only its simplex form is encountered. Evidence from word-formation shows that this is an active process, not just a static restriction, and that post-velars are systematically degeminated.

(69) Degemination in Tiberian Hebrew (McCarthy 1991:76)

a. Plain Root: /jin-teːn/ → [jitteːn]

b. Guttural Root: /jin-ħat/ → [jeːħat]
/nin-ħam/ → [niħam]

Other languages, such as Koryak (Žukova 1972), prohibit geminating ʕ and other pharyngeals. However, geminate pharyngeal/epiglottal consonants are attested in Tashlhiyt (Berber; Ridouane 2008:323).

### 3.3.4 Deletion in Final Position of a Prosodic Constituent

McCarthy (1994:214) shows that coda post-velars (here, the 'gutturals,' namely /χ, ʁ, ħ, ʕ, ʔ, h/) are avoided in (at least some Bedouin dialects of) Arabic. When a post-velar occurs in coda position, epenthesis of short /a/ occurs after the consonant to shift it into onset position.

(70) Avoidance of coda gutturals in Negev Bedouin Arabic (McCarthy 1994:214 citing Blanc 1970)
Plain root: taʃrab 'you drink'
Guttural root: taħ**a**lam 'you dream', taʕ**a**rf 'you know'

McCarthy (1994:214) also notes that "as in Hebrew, there is no epenthesis after word-final or stem-final gutturals." This kind of evidence lends support to an analysis like that presented in Harris and Gussmann (2002) in which syllabic onsets and word-final consonants occupy the same prosodic position.

However, in other languages, post-velars do seem to be avoided word-finally. In Huallaga Quechua, word-final /q/ is deleted, whereas in other positions it is changed to /g/ or spirantized (Weber 1989:452). In Koryak (Chukotko-Kamchatkan), /ʕ/ cannot occur word-finally (although /q/ can) and is actively deleted in that position (Žukova 1972:10-11).

(71) Deletion of word-final /ʕ/ in Koryak (Žukova 1972:31)

a. /ʕəllaʕ/ → [ʕəlla] 'mother'
/ʕəllaʕ-a/ → [ʕəllaʕa] 'by mother'
/ʕəllaʕə-ŋ/ → [ʕəllaʕəŋ] 'to/for mother'

b. /kalaʕ/ → [kala] 'fairy tale character like Baba Yaga'
/kalaʕ-a/ → [kalaʕa] 'by Baba Yaga'
/kalaʕa-ŋ/ → [kalaʕaŋ] 'to/for Baba Yaga'

Like Koryak, Tsova-Tush (Nakh-Daghestanian) deletes word-final /ħ/ in polysyllabic words (Holisky and Gagua 1994:160).[45]

(72) Deletion of word-final /ħ/ in Tsova-Tush (Holisky and Gagua 1994:160)
a. /teps-o-aħ/ → [tepso] 'you are hitting it'
b. /lat'e-aħ/ → [lat'a] 'you help'
c. /kalk-i-ħ/ → [kalki] 'in the city'

### 3.3.5 Positional Contrast Neutralization

In Tigré, the contrast between /ʔ/ and /ʕ/ is neutralized if a pharyngeal, glottal, or ejective consonant follows in the same word (Hayward and Hayward 1989:181 citing Raz 1983:5). Raz (1983:5) writes that "[f]ollowed by a laryngeal [i.e. /ʕ, ħ, ʔ, h/ by his definition; JCS] or by an ejective anywhere in the word, [ʔ] and [ʕ] may be in free variation with one another." He then lists examples, reproduced below in (73).

(73) Tigré words in which [ʔ] and [ʕ] vary freely in word-initial position with a following pharyngeal, glottal, or ejective (Raz 1983:5)

| | | | | |
|---|---|---|---|---|
| /ʔaddəħa/ | [ʔaddəħa] | or | [ʕaddəħa] | 'noon' |
| /ʕad-ħəd/ | [ʔad-ħəd] | or | [ʕad-ħəd] | 'one another' |
| /ʕark'aj/ | [ʕark'aj] | or | [ʔark'aj] | 'bed' |
| /ʕat'aːl/ | [ʔat'aːl] | or | [ʕat'aːl] | 'goats' |
| /ʔat͡s'faːr/ | [ʔat͡s'faːr] | or | [ʕat͡s'faːr] | 'nails' |
| /ʔallət͡s'/ | [ʔallət͡s'] | or | [ʕallət͡s'] | 'hawk' |

## 3.4 Conclusion

The survey of sound patterns presented here showed that post-velar consonants often affect vowel quality, can participate in systems of CV harmony, and are affected in processes which may be explained by perceptual difficulty.

[45]Holisky and Gagua (1994:151) show that /ʕ/ does not occur outside of word-initial position in Tsova-Tush, so it is impossible to determine whether it is just /ħ/ or pharyngeals in general that are avoided in word-final position in Tsova-Tush.

The survey of local effects on vowels showed that although post-velar consonants are commonly thought to exert lowering and backing effects, lowering is much more common, and categorical backing is very rare. In addition, fronting adjacent to pharyngeals is more common than might be thought. Egyptian Arabic and Kabardian both front low /a/ to [æ], and in several Nakh-Daghestanian (Northeast Caucasian) languages, some or all back vowels (/u, o, a/) are fronted adjacent to pharyngeal consonants. In these languages, the fronting effect is likely due to the pharyngeals being produced using a "double bunching" articulation, similar to that of bunched American English /ɹ/, in which the tongue root is retracted and the tongue body is simultaneously fronted. The cause of fronting in Egyptian Arabic is a subject for further research. Other effects on vowels that are unrelated to vowel quality showed that pharyngeal /ʕ/ can lower the pitch (F0) of a preceding vowel, which suggests that the loss of pharyngeal consonants may not only provide clues to historical changes in vowel quality, but possible insights into tonogenesis. A more extensive survey of the effects of post-velar consonants on pitch would enhance our understanding of these possibilities.

The survey of post-velar harmonies revealed interesting parallels between genetically and geographically diverse languages. Languages with post-velar harmonies tend to fall into two types. One type, represented by Arabic, Interior Salish languages, and Tsilhqot'in, have post-velar harmony processes in which the effects of consonants with a primary post-velar articulation are local while the effects of consonants with post-velar secondary articulations are able to affect segments at a distance. The other type, represented by AzJA and Tashlhiyt Berber, have post-velar harmony processes in which all segments can be the targets of post-velar harmony and the domain of the harmony process is defined almost entirely in terms of prosodic categories like the syllable and phonological word. Moreover, speech rate appears to condition the domain of emphasis harmony in Tashlhiyt Berber.

The post-velar harmony processes in Nakh-Daghestanian languages do not fit neatly into either of these types, but share similarities with each. The Rutul system combines a process of consonant harmony that forces uvulars to agree in pharyngealization with a process of CV harmony that spreads pharyngealization from a pharyngealized consonant (underlyingly either uvular or glottal) to a strictly local vowel. Within the Agreement-by-Correspondence framework (Hansson 2001; Rose and Walker 2004), this motivates a system in which multiple correspondence relationships must be possible since separate correspondence relationships among uvulars and among strictly adjacent segments are necessary.

It was also shown that guttural transparency may not exist as previously conceived. Guttural transparency as a process in which vowels must be identical across all post-velar consonants does not occur in any language. Patterns in which vowels must be identical across laryngeal and pharyngeal consonants, here termed non-lingual transparency, are well-attested, but no system requires all vowels to be identical across uvular consonants. The systems that came closest to true guttural transparency had non-lingual transparency in addition to requirements for certain vowels to be identical across uvular consonants. These latter requirements occurred in Iraqw (Cushitic) and Eastern Gitksan (Tsimshianic) were termed dorsal transparency, and they always involved the vowels whose articulations are most similar to those of uvulars, namely high round /u/, and also /o/ and /a/ in Eastern Gitksan. Thus, what has been termed guttural transparency can be separated into non-lingual transparency and dorsal transparency.

# Chapter 4

# The Featural Representation of Post-Velar Consonants

## 4.1 Introduction

By the time the focus of phonological research was beginning to shift away from issues of representation in the late 1980s and early 1990s, the consensus view was that the active articulators of speech should be the basis of the phonological feature system in generative linguistics. However, much less was known then about the articulation of the post-velar consonants than is known now, and most accounts of the representation of post-velar consonants relied on analyzing the patterning of the post-velar consonants in phonological classes. Because of these factors, no consensus had arisen about the representation of the post-velars by the time phonological research shifted its primary focus away from issues of representation. This, combined with their relative cross-linguistic rarity, has led to the post-velars playing a marginal role in phonology.

The post-velar consonants do not deserve this marginal role. The articulatory area over which post-velar consonants are articulated accounts for over approximately 36%, i.e. over one-third, of the total area of the vocal tract in adults (Fitch and Giedd 1999:1515).[1] Moreover, while (supraglottal) post-velar consonants are cross-linguistically rare in proportion to the total number of languages in the world, they are still present in a large number of languages. Uvulars are present in over 150 languages while pharyngeals are present in over 75. Without accurate formal representations for the post-velar consonants, sounds from approximately one-third of the human vocal tract are excluded from phonological theory, and analyses that attempt to explain phenomena involving consonants in the posterior third of the vocal tract are either unreliable or impossible. This is unacceptable if phonological theory is to explain the sound patterns of all human languages.

[1]This figure is the length of the study's "pharynx" portion of the vocal tract, from behind the velum to the glottis, in 10 subjects (3 F, 7 M) of 19-25 years of age. This segment had an average length of 56.4 mm and represented 35.99% of the total average vocal tract length (for the same 10 subjects) of 156.7 mm. The average proportion of the vocal tract composed of the pharynx portion differed in males and females. For males, it was 37.47% (60.4 mm / 161.2 mm) while for females, it was 32.04% (46.9 mm / 146.4 mm; Fitch and Giedd 1999:1515).

The chapter begins (§4.2) with an overview of the history of research into phonological featural representations. This serves as a context for discussing both the intellectual shift away from such research (§4.2.2) and the reasons why featural representations continue to be important in phonology (§4.2.3).

Next, specific proposals for the representation of the post-velar consonants are reviewed to highlight the weaknesses of those proposals and show the need for a different approach to featural representation (§4.3). These previous proposals are subdivided according to their theoretical framework into the earliest representational proposals (§4.3.1) and those that are made within the framework of Feature Geometry (§4.3.2).

In §4.4, I propose a new phonetically-based and contrast-motivated featural representation for the post-velar consonant phonemes attested in the cross-linguistic typological survey in Chapter 2. The contrasts between phonemes that motivate the featural representations are reviewed according to their phonetic dimensions: Place of articulation (§4.4.1.1), possible secondary articulations (§4.4.1.2), phonation type (§4.4.1.3), and manner of articulation (§4.4.1.4). Finally, the features themselves are presented according to those same phonetic dimensions in §4.4.2.

## 4.2 Phonological Features: A Historical Overview

### 4.2.1 Foundations of Research into Phonological Features

Modern research into phonological features began with *Preliminaries to Speech Analysis* (1952) by Roman Jakobson, Gunnar Fant, and Morris Halle. They define a distinctive feature as a phonetic quality whose opposite values are used to produce a minimal phonemic distinction in a language.[2] That is, if a pair of words with distinct meanings differs only according to one phonetic characteristic, that phonetic characteristic is a distinctive feature. The binarity of features can be seen as a product of their definition in terms of minimal pairs:

> Any minimal distinction carried by the message confronts the listener with a two-choice situation. Within a given language each of these oppositions has a specific property which differentiates it from all the others. The listener is obliged to choose either between two polar qualities of the same category, … or between the presence and absence of a certain quality … (Jakobson et al. 1952:3).

In terms of distinctive features, the phoneme is defined as "[t]he distinctive features combined into one simultaneous or … concurrent bundle." These definitions of distinctive features and phonemes are carried into the *The Sound Pattern of English* mostly intact.

What distinguishes the feature system of Jakobson et al. (1952) from later theories of featural representation is its emphasis on the role of perception and acoustics rather than articulation. In discussing "the consecutive stages of sound transmission," the authors propose an "operational hierarchy" of the levels on which the transmission of a (spoken) linguistic signal occurs (12). This

[2] They attribute the discovery of the principle of minimal distinctions to Daniel Jones (Jakobson et al. 1952:2).

hierarchy, which explicitly ranks those levels in order of “decreasing pertinence,” is “perceptual, aural, acoustical, and articulatory (the latter carrying no direct information to the receiver)” (ibid.). Given this hierarchy of importance, the features formulated by Jakobson et al. (1952) are chosen primarily based on perceptual and acoustic characteristics. However, in the majority of cases, the features are defined in terms of both acoustics and articulation. For example, the [flat] feature is clearly perceptually and acoustically motivated, given that the term is borrowed from conventional musical terminology, but it is defined in terms of both acoustics and articulation. Acoustically, “[f]lattening manifests itself by a downward shift of a set of formants or even of all the formants in the spectrum” (31). Articulatorily, “[f]lattening is chiefly generated by a reduction of the lip orifice (rounding) with a concomitant increase in the length of the lip constriction” (ibid.).[3] While articulation is used to help characterize features, it plays a secondary role in defining them because the contrastive features are claimed to be discoverable by speakers only through the perception of “aural” and acoustic cues.

Articulation, however, is the primary basis for the phonological features defined in *The Sound Pattern of English* (henceforth SPE) by Noam Chomsky and Morris Halle (1968). Similar to Jakobson et al. (1952), they define each feature as “a physical scale defined by two points, which are designated by antonymous adjectives: high-nonhigh, voiced-nonvoiced (voiceless), tense-nontense (lax)” (Chomsky and Halle 1968:299). Their point of departure from Jakobson et al. (1952) is the emphasis on articulation, implicit not only in the names of the features, but in the manner in which they are described. While each feature’s articulatory correlates are always described, the feature’s perceptual and acoustic correlates are only described occasionally. Although Chomsky and Halle explicitly state that this is for reasons of space (299), the implicit emphasis is clear.[4] A specific example of the revision of the feature system to reflect an articulatory emphasis is the revision of the features grave/acute and compact/diffuse. While the term “grave/acute” refers to an impressionistic way of auditorily classifying sounds and the term “compact/diffuse” is related to the visual presentation of acoustic characteristics in a spectrogram, the terms Chomsky and Halle choose to replace them with, “backness” and “height,” respectively, are related to displacement of the tongue dorsum from a neutral position (304-306).[5]

Shortly after the publication of SPE, Ladefoged (1971) devised a feature system that was primarily based on phonetics and more explicitly took typological evidence into account. Although

[3]A relevant fact for this study is that “[i]nstead of the front orifice of the mouth cavity, the pharyngeal tract [...] may be contracted with a similar effect of flattening.” Thus, both labialized consonants and, importantly, pharyngealized consonants would be characterized by [flat]. Jakobson et al. (1952:31) assert that pharyngealization and lip-rounding “do not occur within one language,” but in fact they do co-occur in Rutul (Nakh-Daghestanian) and can even co-occur on the same phoneme, e.g. the pharyngealized and labialized uvular stop /$q^{ʕw}$/ (Ibragimov 1978:22). It is puzzling that Jakobson et al. (1952) even made this assertion given the fact that they reference data from “Rutulian, a North Caucasian language” on the very same page.

[4]“We shall describe the articulatory correlate of every feature .... We shall speak of the acoustical and perceptual correlates of a feature only occasionally, not because we regard these aspects as either less interesting or less important, but rather because such discussions would make this section ... much too long.” (Chomsky and Halle 1968:299).

[5]It is now generally recognized that the original articulatory basis for these features is not accurate. Instead of correlating with articulation, the feature [back] correlates with F2 ([+back] = low F2) while the feature [high] correlates with F1 ([+high] = low F1).

the SPE feature system was intended to "represent the phonetic capabilities of man" (Chomsky and Halle 1968:299), that was not the primary goal motivating its composition. Its primary motivation was maximizing theoretical parsimony in stating phonological rules, i.e. positing features that allowed for the simplest formal expression of phonological patterns. In contrast, the motivation behind the feature system of Ladefoged (1971) was to provide a feature system based on phonetic evidence that allowed the phonemic contrasts in the inventories of all languages to be captured (91-95). Ladefoged's feature system is even more strongly based on articulation than the SPE system, but is still not entirely articulatorily-based (e.g. it includes the feature [gravity] which refers to higher- or lower-pitch spectral energy). It also explicitly encodes place of articulation as a multivalued feature, allowing the formal specification of every place of articulation that is designated in the International Phonetic Alphabet, plus labial-velar and labial-alveolar.

Mainstream generative phonology adopted the SPE system, but incrementally modified it in the decades following the publication of SPE in 1968. While Ladefoged's feature system was not generally used in theoretical phonological research, the modifications of the SPE system often relied on phonetic evidence and consequently incorporated aspects of the representation suggested in Ladefoged (1971). For example, with the innovation of Feature Geometry by Clements (1985) and Sagey (1990) (among others), place of articulation, albeit in a less fine-grained form, gained a formal status in mainstream generative phonology in the form of multiple unary place nodes (e.g. [LABIAL], [CORONAL], [DORSAL], [PHARYNGEAL] from Archangeli and Pulleyblank 1994:20) rather than a multivalued place of articulation feature.

### 4.2.2 The Focal Shift From Representations to Derivations

The quantity of research into formal phonological feature representations significantly dropped off around the time that Optimality Theory (OT; Prince and Smolensky 1993) was introduced.[6] Before that time, research into features proceeded under the implicit expectation that "if the representations are right, then the rules will follow" (McCarthy 1988:84). The phonetic bases of the features were refined even further, and new phonetically-based features that were typologically necessary became mainstream, for example, [±ATR] and privative [ATR] and [RTR] to explain vowel harmony processes in Akan and other languages (Ladefoged and Maddieson 1996:300-306; Stewart 1967:196-202). Featural representation was further enriched by imposing internal structure on the features themselves, grouping them and making those groups subsidiary or parallel to others in tree-like structures. This enrichment of the theory was Feature Geometry, and is treated in detail in §4.3.2.

However, after the representations, i.e. phonological features and their structural relationships, became increasingly complex and their definitions became increasingly precise, the rules did not simply follow. Phonologists noticed fundamental inadequacies in how phonological processes, especially those that are output-oriented, could be formalized in a rule-based framework. The need to address these inadequacies shifted the focus of phonological research away from featural represen-

[6]The introduction of Optimality Theory was part of this larger trend and contributed to it, but was not a fundamental cause of the overall shift in research emphasis.

tations and toward modifications of the theoretical mechanisms used to account for phonological interactions and distributional constraints.

One of the most important fundamental inadequacies of the standard rule-based framework was that it could not formally capture the unity of output-oriented rules. The rule-based framework was focused on capturing the processes that transformed underlying representations. Thus, it fared well with phonological interactions in which the transformation itself was the ultimate goal of analysis. However, Kisseberth (1970) identified phonological "conspiracies" in which several rules were needed to ensure that restrictions on the output form held true. A purely rule-based framework provided no way to formalize the fact that certain rules were united by the outputs that they would *avoid* producing. Thus, where it was possible, restrictions on the output of rules were formalized as hard, inviolable constraints. Where this was not possible because of exceptions or because the restrictions on outputs were tendencies rather than absolute prohibitions, hard constraints were not an option, and thus there was no way to formally capture the fact that certain outputs were strongly dispreferred.

Optimality Theory (Prince and Smolensky 1993) came about as a reaction to this problem, and is fundamentally output-oriented. In OT, a form similar to an underlying representation functions as the input to GEN, "a fixed part of Universal Grammar" that generates all the possible modifications of the input form as outputs. These outputs are called *candidates*. These candidates are then evaluated with respect to constraints on the kinds of outputs that are permissible. These constraints are violable, and are posited to be part of a universal constraint set called CON. The constraints can be divided into faithfulness constraints, which evaluate the relationship between the input and output forms, and markedness constraints, which evaluate the structural form of the output. To generate the phonological phenomena that occur in each language, the constraints in CON are ranked with respect to each other. The candidate that violates the most highly-ranked constraints the least of any candidates is the most *harmonic* candidate and emerges as the *optimal* form. This optimal candidate is the form that is actually produced in spoken or signed language.

Underlying representations and featural representations still influence the outcome of Optimality Theoretic derivations, but the output-orientation of OT ultimately trivializes them. Input forms will differ from each other in the extent to which their outputs violate constraints, especially faithfulness constraints. However, the process of Lexicon Optimization (Prince and Smolensky 1993:209) ensures that the input that is the most harmonic with respect to a particular ranking (i.e. that matches the optimal output form most closely) will be chosen by the grammar and consequently also by learners. Lexicon Optimization happens because an input form that incurs the least faithfulness violations will always be more harmonic than an input that incurs more, assuming that the markedness violations incurred by the two inputs are the same. The input whose optimal output candidate will incur the fewest faithfulness violations is the input that is most similar to the optimal output candidate. This means that the choice of input is essentially dictated by the constraints that evaluate its outputs. The representation chosen for the input, then, is less important than the constraints that are chosen.

The principle of Richness of the Base further decreases the importance of featural representation. It "holds that *all* inputs are possible in all languages" (Prince and Smolensky 1993:209), which means that regardless of which input is actually chosen for a derivation, the OT grammar must produce licit forms for a given language from all theoretically possible inputs. Under this view, the attested vocabulary of a language is formally an ultimately random drawing of inputs subjected to the same constraint ranking, i.e. grammar. Other inputs are possible, and should produce licit vocabulary items. This is a desirable characteristic for forming acceptable neologisms and nativizing borrowings from other languages, but it means that the choice of input, and therefore of underlying representation, is in some sense trivial because the constraints of the language have already pre-ordained the fate of every possible output of all possible inputs.

In addition, GEN generates all the possible outputs of an input, and these are all subject to evaluation by CON and the ranking of its constraints in a particular language. This means that even after the underlying representation of an input form is chosen, output forms with every possible modification of that input are evaluated by CON. The choice of input form will impact the derivation, but all the variations of the input form must be considered.

These facts about OT derivations elevate the importance of constraints and their rankings by forcing every possible input and every possible output candidate to be considered. The idea behind considering all these possible forms is that the constraints and their ranking should be robust enough to derive outputs that are licit in the given language for every possible input form. Thus, choosing any particular starting form is far less important than choosing the appropriate constraint ranking.

### 4.2.3 The Importance of Featural Representations

Despite the shift in the focus of phonological research away from featural representations, the choice of features for generative phonology is still important for capturing insights into perception and theory. Features allow phonological theory to encode fundamental facts about the perception of phonemes, i.e. categorical distinctions between speech sounds. Features also abstract over low-level phonetic variation while simultaneously incorporating essential aspects of phonetic substance that play a role in defining contrasts. In addition, the choice of features that represent phonemes significantly impacts the mechanical operation of rules and constraints, sometimes making phonetically simple processes formally complex.

Features reflect the aspects of speech sounds that can be manipulated by speakers to induce phonological contrast. The contrastiveness of speech sounds was fundamental to the feature system of Jakobson et al. (1952). Since then, the importance of this role for features has not generally been questioned although other functions for features, especially capturing natural class generalizations, have garnered more attention. Phonemic contrast is an essential aspect of perception that phonological theory must encode to explain how the sound system of a language operates.

Speakers abstract over a wide range of phonetic variation in producing and perceiving phonemes, and one important function of features is to define which phonetic aspects must occur (perhaps within a more restricted range of variation) for the phonemes to be produced and perceived accurately. This helps to define the kind and amount of phonetic variation in speech sounds that speakers abstract over in establishing phonemes. For example, languages differ in the extent to which sounds belong to various voicing categories. Concretely, word-initial stops which are considered voiceless and unaspirated (e.g. phonetic [p], [t], [k]) in one language are usually perceived as voiced in English. Similarly, initial voiceless stops in English are generally aspirated, and these would be considered phonologically aspirated and phonemically distinct from phonetically unaspirated stops in Hindi. Features, then, reflect the amount of perceptual abstraction over phonetic stimuli that is permissible in each language. This establishes the perceptual categories that distinctively contrast. This function of features prevents phonological derivations from having to directly operate on gradient phonetic data. This is a desirable result for theories that maintain a systematic division between phonetics and phonology (but cf. Flemming 2001).

One of the desiderata of a theory of phonology is that it be explanatory, and featural representations encode phonetic characteristics that explain distinctions between phonemes. It is possible to formulate features in a fully abstract way so that the feature that contrasts [k] and [q] could formally be something like [K V. Q] that makes no claims about the explanation for the contrast.[7] Such a feature only reflects that the contrast is irreducible, under the assumption that, following Jakobson et al. 1952, features must reflect only minimal contrasts, not contrasts where more than two identifiable factors contribute. While a feature like [K V. Q] would be formally adequate, and may possibly even lead to a maximally parsimonious analysis, it is not explanatory. Only when the basis of the phonemic distinction is made clear in the formulation of the feature is that feature in any way explanatory. For example, suppose that the feature that distinguishes /k/ and /q/ is [$\pm$back], then the explanation would be that the distinction between [k] and [q] is one of tongue backing. If the feature were something else, then that would be the explanation. The label that a feature bears reflects what the explanation for a given phonemic distinction is.

Finally, the featural representation of phonemes can impact the formal complexity and predictions of a phonological derivation (either in terms of rules or constraints). To illustrate this in Optimality Theory, suppose that there is a phonological restriction in some language that prohibits round vowels from following labialized consonants or pharyngealized consonants. Assume that there are no consonants in this language that are both pharyngealized and labialized. In the feature system of Jakobson et al. (1952), the feature [flat] identifies both pharyngealized and labialized consonants. Thus, a single markedness constraint in OT, e.g. *[flat]$_C$[+round]$_V$, could force the output condition to hold. However, in a system in which labialized consonants are specified as something like [LAB$^{sec}$] and pharyngealized consonants are specified as something like [PHAR$^{sec}$], two constraints would be needed.[8] These constraints might be, for example, *[LAB$^{sec}$]$_C$[+round]$_V$ and *[PHAR$^{sec}$]$_C$[+round]$_V$. Under an evaluation metric that judges analyses by the number of constraints used, the second analysis with two constraints is inferior. One might contend that this does not matter, and moreover that the overall same number of violations might be incurred between the analysis with one constraint and the analysis with two. However, the analysis that uses

[7]The discussion of the independence of formal representations from phonetic reality here is inspired by Sagey (1990) and Lass (1993), who noticed this independence in synchronic phonology and in historical reconstructions, respectively.

[8]The following sections will review the actual featural specifications that have been proposed for a secondary pharyngeal articulation (pharyngealization). The hypothetical representations [LAB$^{sec}$] and [PHAR$^{sec}$] were chosen to simplify the presentation of a feature specification for a secondary articulation, since the featural specifications for secondary articulations that have been proposed (e.g. in Sagey 1990) often involve tree-like feature geometric structure.

two constraints implies, simply by virtue of using two constraints, that another language might re-rank those constraints. If typological research did not bear out that prediction, the analysis with two constraints would be inferior. Both analyses would correctly derive the hypothetical output condition, however the choice of features would have an impact on the choice between the two analyses, i.e. on how those analyses fare with respect to evaluation metrics. This demonstrates that the choice of features affects derivations, even in Optimality Theory.

## 4.3 Previous Proposals on the Featural Representation of Post-Velar Consonants

Only recently has a body of research been dedicated solely to the featural representation of post-velars. While representations for post-velar consonants were proposed by Jakobson et al. (1952), Chomsky and Halle (1968), and Ladefoged (1971), research dedicated specifically to the featural representation of post-velars was spurred by claims from Hayward and Hayward (1989) and McCarthy (1994) that the post-velars form a phonological natural class. Several prominent issues arose in research dedicated to this issue, namely:

1. The representation of uvulars, which pattern phonologically both with velars and post-velars, depending on the language and other factors;
2. The representation and phonetic description of secondary post-velar articulations, especially pharyngealization and Semitic *emphasis*;
3. The inclusion of glottals in post-velar natural classes;
4. The degree of overlap between post-velar natural classes in particular languages, especially between the Semitic GUTTURAL class and the Interior Salish FAUCAL class; and
5. The phonetic basis of post-velar natural classes.

First, the earliest representations from Jakobson et al. (1952) and Chomsky and Halle (1968) will be reviewed (§4.3.1). Next, to adequately discuss the various proposals on the featural representation of post-velars, it is necessary to review Feature Geometry (§4.3.2), which is the framework in which most proposals since Hayward and Hayward (1989) have been couched. After discussing this framework, the major proposals are reviewed in chronological order.

### 4.3.1 Earliest Proposals

#### 4.3.1.1 Jakobson, Fant, and Halle 1952

Jakobson et al. (1952), which set out the original phonological feature set, does not specifically discuss how the post-velars should be featurally represented, but later work by Roman Jakobson (1962) provides featural specifications for all the phonemes, including post-velars, in North Palestinian Druze Arabic (based on a description by Blanc (1953)). The featural specification of the post-velars, based on Table 1 of Jakobson (1962:510), is given below. A '+' value indicates that the first value of the feature is used while a '-' indicates that the second is used. A '0' value means that the feature is unspecified for the given segment.

| | q | χ | ʁ | ħ | ʕ | h | ʔ |
|---|---|---|---|---|---|---|---|
| vocalic vs. non-vocalic | - | - | - | - | - | - | - |
| consonantal vs. non-consonantal | + | + | + | - | - | - | - |
| flat vs. plain | + | + | + | + | + | - | - |
| nasal vs. oral | - | - | - | 0 | 0 | 0 | 0 |
| compact vs. diffuse | + | + | + | 0 | 0 | 0 | 0 |
| grave vs. acute | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| fortis vs. lenis | + | + | - | + | - | + | - |
| continuant vs. abrupt | - | + | 0 | 0 | 0 | 0 | 0 |
| strident vs. mellow | 0 | 0 | + | 0 | 0 | 0 | 0 |

Table 4.1: The features of post-velar phonemes in North Palestinian Druze Arabic in the Jakobson et al. (1952) feature system (Jakobson 1962:510)

Jakobson views /q, χ/ and /ʁ/ as phonetically uvular (517), but argues that phonologically, they function as the emphatic counterparts of /k, ʃ/ and /ʒ/, respectively. He accepts the traditional classification grouping the uvulars with the emphatic (pharyngealized) consonants as the *mufaxxama* 'heavy' consonants. Jakobson then argues for the parallelism of /q, χ, ʁ/ and /k, ʃ, ʒ/, respectively, as a separate matter by trying to show that the optimal fricatives are strident, and because the velar fricatives would be mellow, they are replaced in the inventory by strident /ʃ/ and /ʒ/. These are then opposed to /χ, ʁ/, which are taken to be inherently strident because of their uvular articulation.

The feature [flat] differentiates the *mufaxxama* (uvular and emphatic/pharyngealized) consonants from their plain counterparts and also differentiates the primary pharyngeals, /ħ/ and /ʕ/ (both flat), from the glottals, /h/ and /ʔ/. However, the primary pharyngeals are not considered emphatic or part of the *mufaxxama* group of consonants (519). Jakobson considers the *mufaxxama* consonants to be consonants with pre-existing feature bundles onto which an additional [flat] feature is imposed, while the pharyngeals are primarily a [flat] feature (ibid.). Although the pharyngeals are not considered to be members of the *mufaxxama* class, the primary pharyngeals look very much like emphatic glottals. This points to a fundamental distinction in Jakobson's view of the Arabic phonemes that is not the point of view of later phonological work, notably McCarthy (1994): There are two phonological classes of phonemes with post-velar articulations in Arabic. The first is the *mufaxxama* or 'heavy' consonants that include the uvulars and the emphatic/pharyngealized pre-velar consonants. The second class is the extra-buccal class, which includes the pharyngeals and laryngeals/glottals, with the former being the emphatic/pharyngealized variants of the latter (518-519). Despite dividing the *mufaxxama* from the extra-buccals, Jakobson (1962) recognizes the fact that the emphatics in both groups are differentiated from their plain counterparts by bearing the feature [flat]. Jakobson's classification of the Arabic phonemes with post-velar articulations can be schematized as in Figure 4.1.

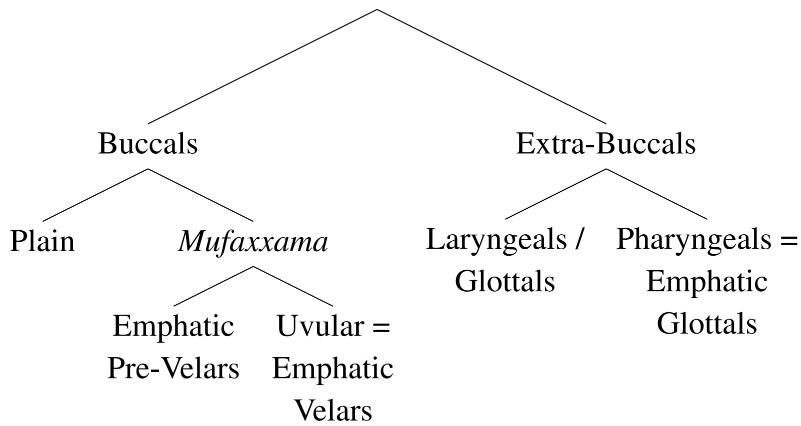


Figure 4.1: Jakobson's phonological grouping of Arabic phonemes (without any differentiations among phonemes that do not contain a post-velar articulation)

#### 4.3.1.2 Chomsky and Halle 1968

The SPE system (Chomsky and Halle 1968) uses articulatory parameters to differentiate phonemes with post-velar articulations. The total articulatory space of the mouth is divided into the anterior and non-anterior regions. The feature [±anterior] is explicitly defined in terms of passive articulation, i.e. place of articulation. The anterior region encompasses all sounds with a constriction "that is located farther forward than the obstruction for [ʃ] [in English; JCS]," which includes the labial, dental, and alveolar consonants (304). All vowels are non-anterior, as are consonants whose place of articulation is "described as palato-alveolar, retroflex, palatal, velar, uvular, or pharyngeal" (ibid.). The glottals are also non-anterior. The [±coronal] feature delineates similar places of articulation to the [±anterior] feature, but is defined in terms of an active articulator, the tongue blade. "Coronal sounds are produced with the blade of the tongue raised from its neutral position," and include the dental, alveolar, palato-alveolar, and retroflex consonants (ibid.).

The post-velar phonemes are all non-anterior and non-coronal, and they are distinguished from one another by parameters describing the displacement of the tongue body from a neutral position. These parameters are the formal features [±high], [±low], and [±back]. The only theoretically possible combination of these parameters that must be ruled out on theory-external grounds is [+high, +low], which is physiologically impossible since the tongue body cannot be displaced both lower and higher than neutral at the same time. The following table, adapted from Table 2 of Chomsky and Halle (1968:305), shows the featural specification of the non-anterior, non-coronal sounds, which includes the palatals, velars, uvulars, pharyngeals, and glottals.

| | *Palatal* | *Velar* | *Uvular* | *Pharyngeal* | *Glottal* |
|---|---|---|---|---|---|
| high | + | + | - | - | - |
| low | - | - | - | + | + |
| back | - | + | + | + | - |

Table 4.2: SPE's featural specification for non-anterior, non-coronal sounds (Table 2 of Chomsky and Halle 1968:305)

In this featural representation scheme, the post-velar consonants are the non-high, non-anterior, non-coronal consonants, and they are differentiated from each other by the degree to which they are back and low. Under this featural representation of the post-velars, the uvulars can be said to be the back consonants, the glottals can be called the low consonants, and the pharyngeals are both back and low. Non-anterior, non-coronal secondary articulations replace any '-' values of the tongue body features, [high, low, back], for the primary consonant with any '+' values of those features for the secondary articulation (Chomsky and Halle 1968:305-307). For example, dental/alveolar consonants are [-high, -low, -back], but when they are pharyngealized, they become [-high, +low, +back], since primary pharyngeals have [-high, +low, +back] tongue body features.

This featural specification system offers some substantial formal benefits. First, the post-velar consonants (the uvulars, pharyngeals, and glottals) can all be grouped as a phonological natural class by their shared featural specifications: [-anterior, -coronal, -high]. Within this class, the pharyngeals can easily be grouped with the uvulars or with the glottals. The pharyngeals and uvulars can be grouped by their shared [+back] specification, and the pharyngeals and glottals can be grouped by their shared [+low] specification.

However, the featural representations offered by SPE cannot account for the palatalized uvulars found in Kryz (/$q^j$'/ ;Nakh-Daghestanian) and the Northwest Caucasian languages Abaza (/$q^j$'/), Abkhaz (/$q^j$'/), and Ubykh (/$q^j$, $q^j$'/).[9] The reason for this is that palatals are [+high, -low, -back] and uvulars are [-high, -low, +back]. Thus, a palatalized uvular would have the featural specification [+high, -low, +back] (as well as [-anterior, -coronal]). This is the exact featural specification used for velars and velarized consonants. The prediction, then, is that a phonologically palatalized uvular should be realized as a velar since there is no featural distinction. However, in Kryz, Abaza, and Abkhaz, /$q^j$'/ must stand in contrast with the phonemes /k'/ and /$k^j$'/. In Ubykh, /$q^j$'/ contrasts with /$k^j$/ and /$k^j$'/, and the absence of plain /k/ and /k'/ is a gap in the inventory. These schematic phonemic facts are summarized in Table 4.3.

[9] For the Northwest Caucasian languages, the fundamental descriptive inadequacy of the SPE features was first noticed by Colarusso's 1975 dissertation (later published as Colarusso 1988). The existence of pharyngealized uvulars was confirmed for the Bzyb dialect of Abkhaz by Catford (1983). Bessell (1992:14) also discusses this inadequacy of the SPE representation.

| | | | |
|---|---|---|---|
| Kryz | /$q^{j}$'/ | contrasts with | /k', $k^{j}$'/ |
| Abaza | /$q^{j}$'/ | | /k', $k^{j}$'/ |
| Abkhaz | /$q^{j}$'/ | | /k', $k^{j}$'/ |
| Ubykh | /$q^{j}$, $q^{j}$'/ | | /$k^{j}$, $k^{j}$'/ |

Table 4.3: Contrasts between velar and palatalized uvular phonemes in four languages of the Caucasus

A much more serious criticism of the SPE feature system is that the phonetic bases of at least some of its features obscure more direct explanations, are incorrect, or both. The feature [±low] has been assailed for incorrectly representing vowel articulations and incorrectly suggesting a lingual basis for the articulation of pharyngeals and glottals. Writing about the need for a revised understanding of how vowels are articulated, Esling (2005:23) argues against the existence of "an independent lingual lowering articulator" and instead advocates viewing the vowel space in terms of a more complex interaction between the tongue, jaw, and larynx. With regard to consonants, it has been widely recognized that the larynx itself, rather than the tongue body, is responsible for the primary articulation of the glottal consonants (Catford 1977a:163; Ladefoged 1971:41). Similarly, Moisik and Esling (2011) have described pharyngeal articulations in terms of constriction of the epilaryngeal tube (or epilarynx) using the feature [±constricted epilaryngeal tube] (= [±cet]). These facts argue against the need for the feature [±low]. Lingual articulations in the pharynx region are, however, possible and are used in the articulation of American English /ɹ/ and some pharyngeal approximants, such as Arabic /ʕ/ (Delattre 1971). However, this is not viewed as activity of the tongue body, but of the tongue *root*, and has been captured by the features [±Advanced Tongue Root / Retracted Tongue Root] ([±ATR/RTR]; Stewart 1967; Halle and Stevens 1969). Further discussion of the phonetic bases of features related to the post-velar consonants is deferred to §4.4.2.

#### 4.3.1.3 Ladefoged 1971

The feature system proposed by Ladefoged (1971) is similar in many respects to that of Chomsky and Halle (1968), but has a different emphasis on what phonology should explain. Ladefoged (1971) advances a view of the cline from phonetics to phonology that helps to explain the differences between the goals of the two theories.

| | |
|---|---|
| *Abstract* | Underlying lexical contrast |
| ↑ | Surface phonemic contrast |
| ↓ | Systematic phonetic description |
| *Concrete* | Empirical phonetic data |

Table 4.4: The cline from phonetics to phonology based on Ladefoged (1971)

In contrast to the approach of Chomsky and Halle (1968), which emphasizes the importance of phonological underlying forms in a language's lexicon, Ladefoged (1971) prioritizes phonemic contrasts that are apparent in surface data. For determining a set of phonological features, Ladefoged (1971:1) writes that "[i]t does not matter whether or not particular contrasts occur *among underlying forms* [emphasis mine]; a phonological theory must be capable of specifying all the phonetic events in a language." In Ladefoged's view, his own feature system is meant to account for cross-linguistic surface phonemic contrasts while Chomsky and Halle (1968)'s is meant to account for underlying lexical contrasts. Neither theory dismisses the importance of either underlying lexical contrast or surface phonemic contrast, but the theories concentrate mainly on one level and hope to incidentally explain the other. Thus, the feature system in Ladefoged (1971) is meant to account for surface phonemic contrast, but also incidentally underlying lexical contrast, with the assumption being that the feature set will be empirically adequate, but not necessarily maximally parsimonious.

In Ladefoged's feature system (1971:92-94), the phonological representation of the post-velars is purposefully very close to their phonetic description. Place of articulation is represented directly as either uvular, pharyngeal, or glottal. There is no contrast between pharyngeal and epiglottal in Ladefoged's system. Glottal stop can be represented in two ways, either as a consonantal stop ([Articulatory place: Glottal] and [Stop: Stop closure]) or as a kind of glottal stricture ([Glottal stricture: Glottal stop]). Two other features are especially important for the representation of post-velars: Backness and Tension. The Backness feature is defined as "the degree to which the tongue approaches the soft palate or the back wall of the pharynx" and has two possible values: 1) no tongue retraction and 2) body of tongue retracted (Ladefoged 1971:75,93). This feature encompasses the original articulatory definition of [+back] in Chomsky and Halle (1968), but corresponds most closely with the lingual articulation designated as "raised" in Esling (2005:18) in which the tongue is pulled "upward and backward," i.e. toward the soft palate and toward the upper pharynx. The Tension feature is defined as "the degree to which the root of the tongue is pulled forward so that the tongue is bunched up lengthways" and has three possible values: 1) tongue hollowed, 2) no intrinsic tongue contraction, and 3) tongue bunched (Ladefoged 1971:75,93). This feature captures the distinction between tense and lax vowels, with tense vowels having the "tongue bunched" value and lax vowels having the "tongue hollowed" feature. These features appear to correspond to combinations of the features [$\pm$ATR] and [$\pm$RTR] such that "tongue hollowed" is [-ATR, +RTR], no intrinsic tongue contraction is [-ATR, -RTR], and "tongue bunched" is [+ATR, -RTR]. This feature is not used for consonant place. While in some frameworks, pharyngealization is [+RTR], pharyngealization in Ladefoged's system is the same as that of Chomsky and Halle. That is, the features [+back, +low] are added to a consonant's primary place to represent pharyngealization. In this respect, Ladefoged's feature system encounters the same descriptive problems as that of Chomsky and Halle (1968).

## 4.3.2 Feature Geometry

### 4.3.2.1 Brief Overview of the Framework

At issue in featural representation is not just the features themselves, but their possible groupings. The earliest proposals for the featural representations of phonemes group the features as unordered bundles (Jakobson et al. 1952:3-4; Chomsky and Halle 1968:296). Unordered bundles reflect the view that "phonological features are simultaneous and unstructured at the phonological level, and [...] all instances of surface-level feature overlap must be analyzed as an effect of phonetic implementation" (Clements 1985:226). However, Chomsky and Halle (1968:299-300) anticipated the possibility of hierarchically grouping features, presumably on the basis of phonetic dependencies. With the advent of non-linear phonology, epitomized by autosegmental phonology (Goldsmith 1976), it became possible to formally model these hierarchical groupings in terms of phonological tiers.

Feature Geometry is based on evidence that "certain sets of features consistently behave as a unit" in phonological processes and on the idea that each of these sets should "constitute a unit in phonological representation" (Clements 1985:226). The features function as the terminal nodes in a tree-like hierarchy of units of phonological representation. The features are grouped together by being linked to the same dominating node. In the feature geometry of Sagey (1990), which was adopted as a starting point for most work in Feature Geometry, this first-level dominating node corresponds to an active articulator (e.g. labial, coronal, etc.).[10] These articulator nodes are further grouped by being linked to a dominating node (e.g. place). This leads to a hierarchical structure that resembles a syntactic tree (though not a strictly binary one). The original feature geometry of Clements (1985) and the revised feature geometry of Sagey (1990) are given in the figures below. Both figures come from Sagey (1990).

[10]The words "Feature Geometry" are capitalized when referring to the theory in general and are in lowercase when referring to a particular claim about how features should be hierarchically organized.

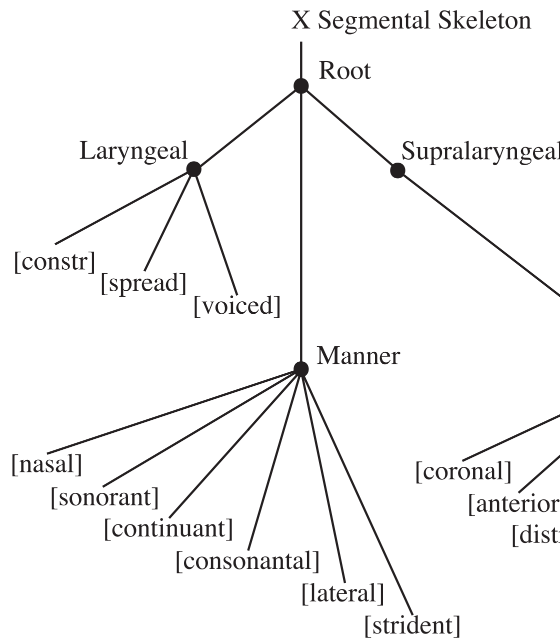


Figure 4.2: The feature geometry of Clements (1985) based on the 2D diagram in Sagey (1990:20)

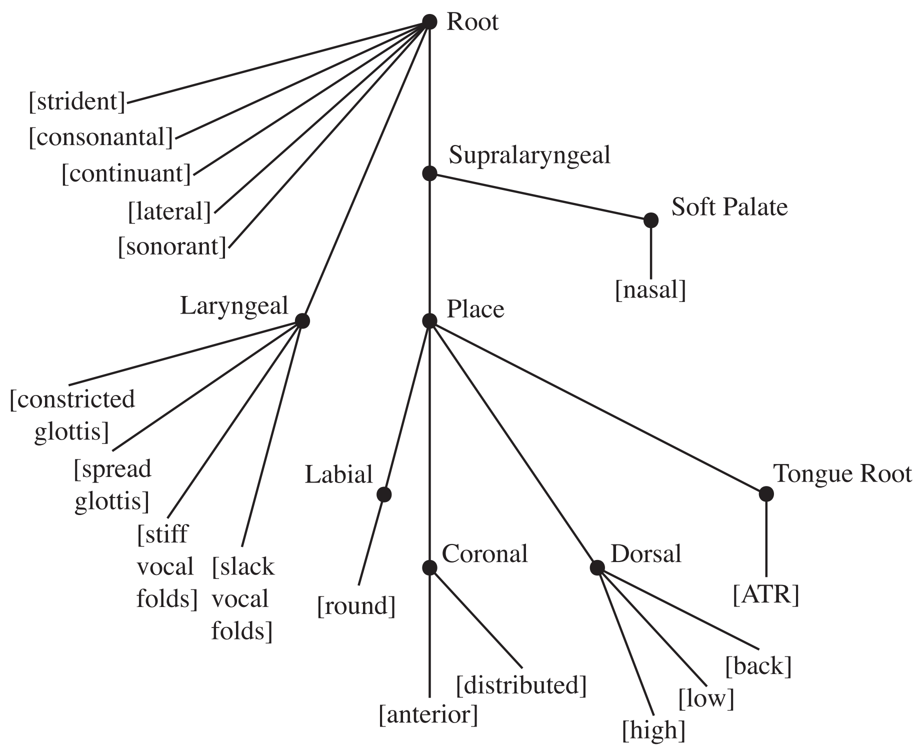


Figure 4.3: The feature geometry proposed by Sagey (1990:205)

The evidence for grouping features into nodes comes from phonological processes and constraints while the basis for most of the nodes comes from articulatory phonetics. Evidence for nodes comes from phonological processes that, for example, spread the values for all the features that are proposed as belonging to the node. If the features (or, technically, their values) consistently spread together, this is evidence that they are somehow linked. From a logical point of view, this link need not be phonetically natural, but often phonetics is the basis for the link (Sagey 1990:13). In any case, a more parsimonious theory results from positing a node that links the features because then only a single node needs to be recognized in the formalization of phonological processes. This lowers the theoretical "cost" of the processes according to evaluation metrics in which processes that are formalized with more representations are more costly than those formalized with fewer.[11]

The evidence for the first-level non-terminal nodes that link the features in Sagey's model is phonological, but the basis for the nodes is taken to be the active articulators.[12] For example, in Fanti Akan (Kwa), the alveolar trill /r/ assimilates to a following vowel, and is "palatalized before /i/, velarized before /u/, and ... the back of the tongue is low before /a/" (Welmers 1946:13; Sagey 1990:109). The features [high], [back], and [low] act as a unit in that they all spread from the vowel onto /r/. This is evidence that they can all be linked under a Feature Geometric node. Because these features are all articulated with the tongue body, or dorsum, the node to which they are linked is called the Dorsal node (Sagey 1990:109). Sagey (1990:93-112) justifies the Labial, Coronal, and Dorsal articulator nodes using similar phonological evidence from at least three languages for each node. However, Sagey does not justify the tongue root node in a corresponding fashion.[13] Czaykowska-Higgins (1987) fills this gap, and her account of the tongue root node is summarized in 4.3.2.2.

The following sections summarize proposals for the representation of post-velar consonants that are formulated in terms of Feature Geometry. Proposals framed in terms of Feature Geometry are motivated by the phonological patterning of post-velar consonants, which is interpreted as evidence of natural class behavior. These summaries focus on the phonetic characterizations of the post-velar consonants, their formal representations, and the predictions that these proposals make about natural class behavior.

#### 4.3.2.2 Czaykowska-Higgins 1987

Czaykowska-Higgins (1987) provides evidence for an independent Tongue Root node, arguing that although the distinctions between vowels and the modification of vowels is similar in languages

[11] An assumption behind such a metric is that simpler formalizations "correspond to more natural (or more common) phenomena" (Padgett 2002:83).

[12] Clements (1985) and Sagey (1990) refer to the non-terminal nodes as "class nodes." However, because the first-level nodes are active articulators in Sagey's feature geometry, this study refers to those nodes (Laryngeal, Soft Palate [Velum], Labial, Coronal, Dorsal, and Tongue Root) as "articulator nodes." Any time class nodes need to be referred to as a group, one can use the term non-terminal nodes without a difference in meaning. Sagey used the term "articulator" to refer only to the nodes immediately dominated by the Place node, which excludes the Laryngeal and Soft Palate nodes. Although the soft palate, or velum, is not normally considered an active articulator, it is reasonable to view it as such because it can be independently manipulated for the purpose of producing nasal consonants.

[13] The feature geometry in the 1986 dissertation on which Sagey (1990) is based did not include a tongue root node.

that display some kind of tongue root behavior, there are two fundamental types of tongue root behavior (Type I and II) that are differentiated by the additional articulations with which they are associated. This is used to motivate the existence of a Tongue Root node that dominates two features, [±upper pharynx] and [±lower pharynx]. These two features help to distinguish segments in the Type II languages. The inclusion of the Tongue Root node itself (without any specification of its features) appears to be used to represent the [-ATR] vowels. This is possible because "the only way [the tongue root] can form a constriction is by retracting" (12). Thus, including any indication of tongue root activity is enough to signal retraction somewhere in the pharyngeal region (ibid.).

Languages of the first type (Type I) involve tongue root activity that acts "in conjunction with various other phonetic properties, such as voicing, pitch, and phonation distinctions which are usually associated with laryngeal mechanisms" (2). In Type I languages, the tongue root is used as a means to modify vowel quality, not to articulate a consonant (11). This allows for greater freedom in the tongue root articulation, which justifies not being required to specify values for the two features that are proposed as being dominated by the Tongue Root node.

Languages of the second type (Type II) involve tongue root activity that is diagnostic of "a relationship between vowel quality and the presence of uvular, pharyngeal, or retracted consonants" (3). In these languages, the uvular, pharyngeal, and retracted consonants can affect vowels in a different way, and this serves as the motivation for two new features that allow three sub-places of articulation in the pharynx region to be differentiated. The [+upper pharynx, -lower pharynx] segments are uvular or uvularized, and [-upper pharynx, +lower pharynx] segments are pharyngeal or pharyngealized. The existence of pharyngealized uvulars in Abaza, Abkhaz, and Ubykh motivates having two features to differentiate the uvulars and pharyngeals rather than one, since pharyngealized uvulars can then be represented as [+upper pharynx, +lower pharynx] (13). Czaykowska-Higgins (1987:13) claims that [-upper pharynx, -lower pharynx] characterizes rhotacization on the basis of work by Lindau (1978) which claims that the basic articulation of rhotacization is retraction of the tongue body at a position between where uvulars and pharyngeals are articulated.

| | *Uvulars* | *Pharyngeals* | *Pharyngealized Uvular* | *Uvularized Pharyngeal* | *Rhotacized Segment* |
|---|---|---|---|---|---|
| Upper Pharynx | + | - | + | + | - |
| Lower Pharynx | - | + | + | + | - |

Table 4.5: The featural representation of supralaryngeal post-velar segments as given by Czaykowska-Higgins (1987:13)

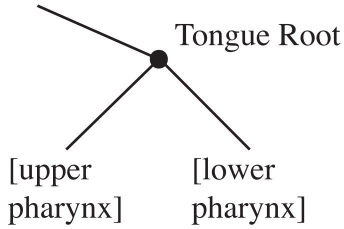


Figure 4.4: The portion of the overall Feature Geometry suggested for representing tongue root articulations in Czaykowska-Higgins (1987)

Czaykowska-Higgins' proposal is well-motivated and offers a number of advantages over the simpler [±ATR] approach in Sagey (1990). However, adopting the Tongue Root node and its two features ([±upper pharynx] and [±lower pharynx]) as the main means of representing post-velar articulations is problematic because it obscures the role of non-lingual articulations. Subsequent articulatory research by Esling, Moisik, and others has shown that the articulators for the various places designated by Czaykowska-Higgins' feature system are distinct, which leads to the possibility that not all the combinations of the features [±upper pharynx] and [±lower pharynx] can be directly compared. For example, the articulations represented by [+lower pharynx] are most likely achieved by constriction of the epilarynx while the articulations represented by [+upper pharynx] and [-upper pharynx, -lower pharynx] are achieved by lingual constrictions. Nevertheless, the division of post-velar articulations into upper, mid, and lower pharyngeal articulations captures valuable descriptive insight.

#### 4.3.2.3 Hayward and Hayward 1989, McCarthy 1991 & 1994

The most influential works on the featural specification of post-velars were Hayward and Hayward (1989) and McCarthy (1991, 1994). These works provided phonological evidence from a number of Cushitic and Semitic languages that the post-velar consonants, sometimes subsets and sometimes as a whole, comprise a natural class in synchronic phonological processes and distributional constraints. This section concentrates on the proposals made for featural representations and the phonetic evidence mustered in defense of those representations.

The proposals made by Hayward and Hayward (1989) and McCarthy (1991, 1994) are notable for being explicitly based on place of articulation rather than active articulators, in contrast to the articulatory basis of most features in Sagey (1990). Hayward and Hayward (1989) concentrated on defending the existence of a feature, [guttural], which characterizes all the post-velar consonants. They offered few details on the phonetic motivation for the feature, but proposed that it was based on a region of articulation shared by all post-velars rather than a shared articulator.

McCarthy (1994) refines the discussion in McCarthy (1991) of the phonetic basis of his [pharyngeal] feature, which is inspired by the feature [guttural] in Hayward and Hayward (1989). He proposes that the feature [pharyngeal] designates the whole posterior region of the vocal tract, starting from the oropharynx and ending at the larynx. His definition of the [pharyngeal] feature is couched in Perkell's (1980:338) idea that distinctive features are "orosensory patterns corresponding to distinctive sound producing states." The distinctive sound producing state for the [pharyngeal] feature is claimed to be relatively higher F1 (McCarthy 1994:199). He claims that the orosensory pattern that defines this region is less sensory acuity than the front of the vocal tract, and he argues that this motivates his treatment of the whole pharyngeal region as a single unit because it has the same overall sensory acuity as more anterior major articulators. He cites findings by Penfield and Rasmussen (1950) that the cortical area devoted to the pharyngeal region (as defined by McCarthy 1994) is approximately half the size of the cortical area devoted to the tongue. McCarthy (1994:200) notes that the tongue is represented by two major articulators in phonological theory, the corona and dorsum, and therefore the size of the cortical area devoted to the pharyngeal region is approximately that allocated for other major articulators.[14] The formal Feature Geometric proposal McCarthy (1994:223) makes is that the Labial, Coronal, and Dorsal nodes are separated from the Place node by an intermediate node, Oral, and that Pharyngeal is a major articulator like Labial, Coronal, and Dorsal, but is nested directly below Place. This puts it on par with Oral, which captures McCarthy's insight that Pharyngeal represents the entire posterior area of the vocal tract but is phonologically like an articulator.

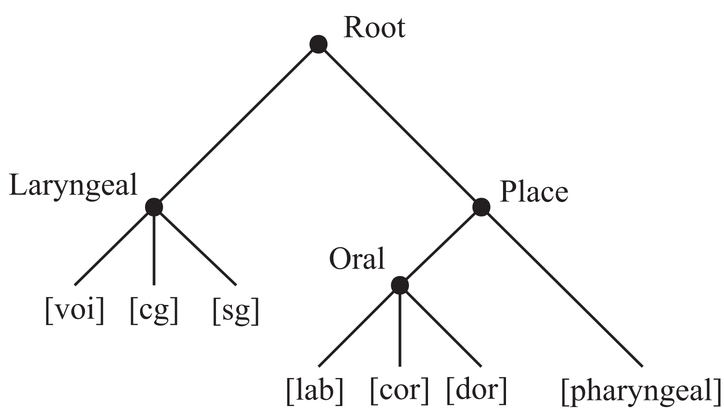


Figure 4.5: The feature geometry proposed by McCarthy (1994:223) (many features which are not relevant to a discussion of post-velars are not shown)

McCarthy (1994:221) uses only these major place categories to describe the classes of consonants that are treated as guttural. Pharyngeals and glottals, where the latter pattern as gutturals, are represented by just the [pharyngeal] node.[15] Uvulars bear both [pharyngeal] and [dorsal]. The emphatic consonants are treated as uvularized, and thus bear an oral articulator, such as [coronal], along with both [dorsal] and [pharyngeal], since these latter two features define uvular articulations.

[14]McCarthy (1994:225) notes in an endnote that there are very serious problems with the model in Penfield and Rasmussen (1950), but he was able to find no better alternate evidence.

[15]McCarthy does not explicitly address the question of whether his major place designations are to be treated like Feature Geometric nodes, i.e. Labial, Coronal, etc. as in Sagey (1990), or as terminal features that are either privative, e.g. [labial], or equipollent, [±labial]. For the purpose of easier comparison with previous proposals, I refer in prose to McCarthy's [labial], [coronal], [dorsal], and [pharyngeal] as "nodes," but they should most likely be interpreted as privative features.

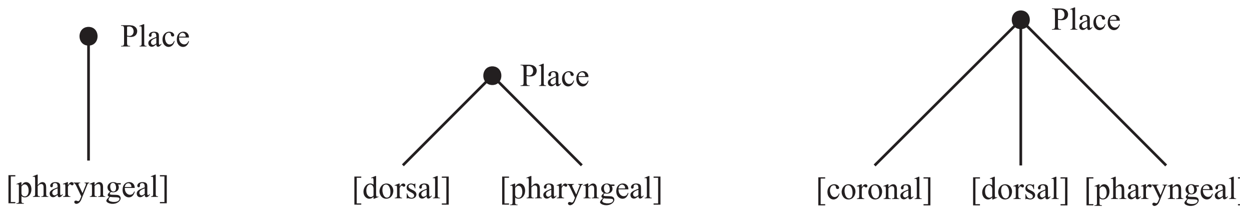


Figure 4.6: Featural representations for (from left to right) 1. pharyngeals and guttural glottals, 2. uvulars, and 3. coronal emphatics (McCarthy 1994:221)

McCarthy's featural representations do not offer enough detail to distinguish pharyngealized uvulars from plain uvulars. Because uvulars are already [pharyngeal] and the feature [pharyngeal] is the only one that can be used to represent pharyngealization, there is no way to signal that a uvular consonant bears distinctive pharyngealization. This contrast exists in Tsez, Rutul, Tsakhur, and Abaza. An even more elaborate system is present in Khwarshi (Kwantlada dialect), in which the phonemes /k, $k^{\text{ʕ}}$, q, $q^{\text{ʕ}}$/ are all opposed.[16] In McCarthy's feature representations, /k/ would bear the [dorsal] feature and /$k^{\text{ʕ}}$/ would bear the features [dorsal] and [pharyngeal]. However, /q/ would also be specified as [dorsal] and [pharyngeal]. Therefore, /$k^{\text{ʕ}}$/ could not be contrasted with /q/, which in turn could not be contrasted with /$q^{\text{ʕ}}$/.

#### 4.3.2.4 Bessell 1992

Bessell (1992:193) proposes a featural representation for the uvulars, pharyngeals, and glottals that hybridizes the approaches of Czaykowska-Higgins (1987) and McCarthy (1991, 1994). She presents representations (shown in Figure 4.7) for uvulars, pharyngeals, glottals, and pharyngealized coronals ('retracted' consonants in Salish and 'emphatics' in Semitic).[17]

[16] /q/ is realized as [$\widehat{q\chi}^{h}$] in Khwarshi (Khalilova 2009:13-22) and is listed that way in the typology presented in §2.2.4.

[17] These segments most likely have different realizations in the two families, as well as different realizations in each language or dialect which possesses them. This variation is glossed over here to demonstrate their parallelism in Feature Geometric representations.

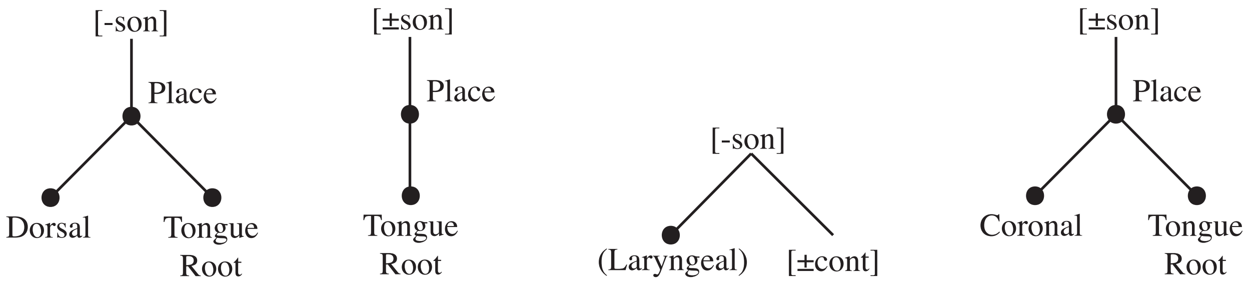


Figure 4.7: Featural representations for (from left to right) 1. uvulars, 2. pharyngeals, 3. glottals, and 4. pharyngealized coronals (retracted consonants) based on data from Coeur d'Alene (Bessell 1992:193)

The representations presented are like those of Czaykowska-Higgins (1987) in that the tongue root is considered to be a fourth place node. However, unlike Czaykowska-Higgins, Bessell does not associate any features with the tongue root node (such as [upper pharynx] and [lower pharynx]). Thus, uvulars are modeled as having both the tongue root node and the dorsal node, similar to how uvulars have both the dorsal and pharyngeal nodes in McCarthy (1994). Bessell (1992) argues that glottals are not guttural (or faucal) in Interior Salish (cf. Rose 1996), and thus represents glottals without a tongue root node. Glottals are argued to be placeless consonants which bear a continuancy feature (Bessell 1992:371).

Bessell's (1992) featural representation shares some of the same weaknesses of Czaykowska-Higgins (1987) and McCarthy (1994). First, the fourth node, which represents pharyngeals, is still considered to be the tongue root, and this is phonetically inaccurate (see §4.4.2.1). Finally, the featural representations proposed by Bessell (1992) are unable to distinguish pharyngealized velars, plain uvulars, and pharyngealized uvulars for the same reasons that McCarthy's (1994) feature representations are unable to do this (§4.3.2.3).

#### 4.3.2.5 Rose 1996

The featural representations proposed in Rose (1996) are meant to capture cross-linguistic variation in the patterning of post-velar consonants while accounting for the effects that the post-velars have on vowels. These representations build on insights from Bessell (1992) and McCarthy (1994) while incorporating evidence from a number of other languages, including Tamazight Berber, Besleney (dialect of Kabardian; Northwest Caucasian), Nisgha (Tsimshianic), Kashaya (Pomoan), and Kera (Chadic).

One of the key insights in Rose (1996) is her use of Avery and Rice's (1989) Node Activation Condition to ensure that the glottal consonants (/h, ʔ/) are placeless only when there is no other segment bearing a "primary Pharyngeal node" (79), i.e. no other core member of the guttural natural class. The Node Activation Condition states:

> If a secondary content node is the sole distinguishing feature between two segments, then the primary feature is activated for the segments distinguished. Active nodes must

be present in the underlying representation (Avery and Rice 1989:183, Rose 1996:78).

This allows the glottals to be represented in two ways: 1) as placeless consonants when no consonants with a Pharyngeal node are in the inventory, or 2) as the most basic Pharyngeal node consonants possible when other consonants that bear a Pharyngeal node are in the inventory. The representations for the glottals and other post-velar consonants in Rose (1996:80, ex. 16) are given below.

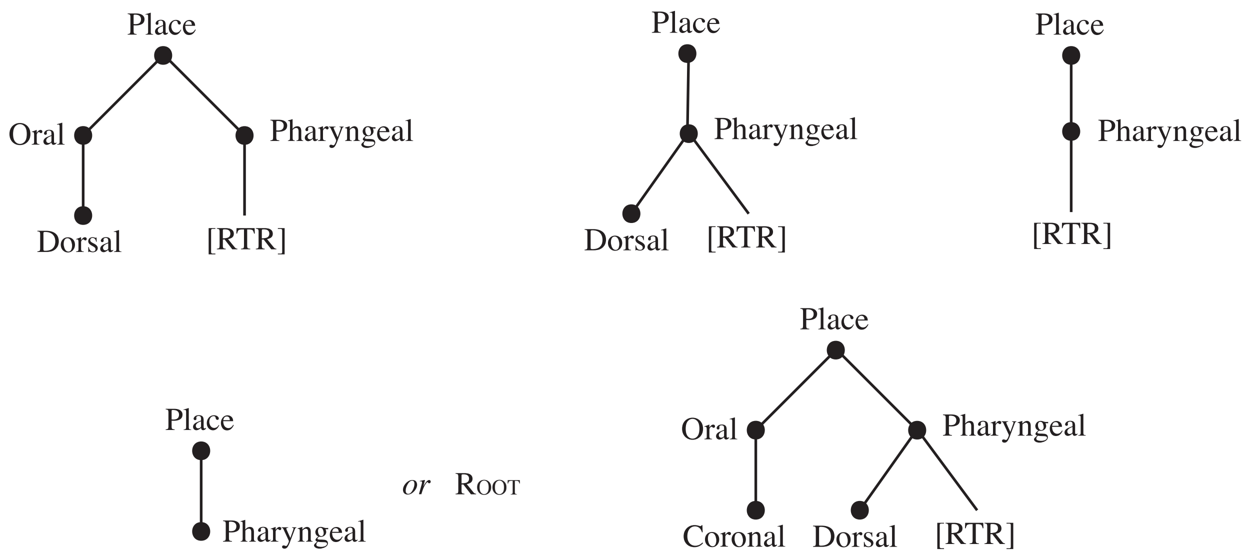


Figure 4.8: The featural representations of Rose (1996:80, ex. 16) for (top to bottom and left to right): 1. Uvular /q/, 2. All other uvulars, 3. Pharyngeals, 4. Laryngeals (Guttural and Placeless), and 5. Emphatics

These representations, combined with the Node Activation Condition, do an impressive job of characterizing natural class behavior among the post-velar consonants. However, empirical data casts strong doubt on her theoretical explanation for the variability in the patterning of the glottal consonants. Given the Node Activation Condition, laryngeals are placeless unless a "segment with a primary Pharyngeal node" is also present in the language (Rose 1996:79). The phoneme /q/ bears only a secondary Pharyngeal node, and consequently, "uvular stops do not force activation of the Pharyngeal node on laryngeals" (81). Thus, the prediction is that a language which has only the underlying phonemes /q/ and glottals should not show effects that suggest that either of these segments are guttural.

However, Filomeno Mata Totonac represents a direct counterexample to this prediction. It has only only /q, ʔ/ in its post-velar consonant phoneme inventory and, as shown in §3.1.1, these consonants pattern together in causing vowel lowering (McFarland 2009:35-37).[18] Vowel lowering

[18]Note from §3.1.1 that the non-uvular phonemes /x, n/ have uvular allophones that result from processes of uvular harmony and assimilation, respectively (McFarland 2009:35-37).

is considered evidence of the guttural status of post-velar consonants, and leads to the expectation that both /q/ and /ʔ/ bear Pharyngeal nodes, which is predicted never to be able to occur under Rose's (1996) framework.

## 4.4 New Proposal for the Phonological Feature Representation of Post-Velar Consonants

Previous proposals on how to represent the post-velar phonemes using features have been hampered by the lack of two critical empirical tools: 1) a full typology[19] and 2) a deep and accurate articulatory phonetic description. Chapter 1 fills the need for a full typology, and Moisik (2013) provides the most extensive articulatory phonetic description of the post-velar consonants to date. With both a full typology and extensive phonetic information, it is possible to understand the range of phenomena that need to be accounted for and to decide which phenomena should be accounted for by featural representations as opposed to other theoretical devices.

Evidence from this fuller typology and new articulatory findings shows that fewer phonemic contrasts exist among the post-velar consonants in any given language than are articulatorily possible. Nevertheless, some of the articulatory possibilities that are not used for making phonemic contrasts are still implemented in the production of the post-velar consonants. These articulations are still able to influence phonological processes even though they are not used to establish phonemic contrasts. For example, contraction of the middle genioglossus produces a "tongue bunching" articulation (similar to that in American English /ɹ/) that is used to realize a post-velar constriction for pharyngealized vowels in Lak. This "tongue bunching" action produces a more anterior, pre-velar palatal constriction, which explains why the pharyngealized vowels in Lak are able to palatalize the velar phonemes and /l/ (Moisik 2013:482-486; Anderson 1997:974).

The influence of specific aspects of the articulation of post-velar consonants on phonological processes has prompted proposals for modifying the formal representations of these consonants. Previous research in this area has assumed that phonetic facts should play a primary role in defining the features to be used in formally modeling the post-velar consonants in phonology (e.g. the proposed basis for the feature [pharyngeal] in McCarthy 1994:198-202). It has also been assumed that these representations should explain not only phonemic contrasts between segments, but also the groupings of segments as natural classes in phonological processes and constraints (Rose 1996:81). The apparent challenge in finding the best representations for the post-velar consonants is to get the most phonetically accurate features to account for the most common phonological classes observed in sound patterns.

Before attempting to rise to this challenge, however, it is worth questioning both whether the basis for the features should be phonetic and whether the representations themselves should bear the burden of explaining the phonological class behavior. The original basis for phonological

[19]Because not every human language has been documented (nor can it even be agreed which linguistic varieties should be called "languages"), it is impossible to provide an absolutely full typology. Instead, a "full" typology means a typology that surveys all of the extant literature to find all the recorded attestations of a phenomenon. In practice, the typology here is not completely "full" even in that sense, but it is fuller than many other typologies.

features was minimal contrast, as explained in Jakobson et al. (1952). This basis was carried into Chomsky and Halle (1968). However, Chomsky and Halle (1968) explicitly introduced the idea that features should be responsible for formally explaining why certain sounds frequently pattern together as targets or triggers in sound patterns. New proposals have primarily focused on better explaining phonological class behavior by modifying the phonetic bases and definitions of the features. The idea that features should explain phonological classes has generally not been questioned (but cf. Flemming 2005 andMielke 2008).

The proposal that I advance here, which returns in spirit to the motivation for phonological features in Jakobson et al. (1952), is to use the phonemic contrasts attested in the world's languages as the basis for a limited phonological feature set that can formally represent all the cross-linguistically attested post-velar consonants. This feature set is universal in the sense that it can capture the phonological contrasts that are necessary for distinguishing post-velar consonant phonemes in all languages.[20] Because there are fewer phonemic contrasts attested among the post-velar consonants than are articulatorily possible, the phonological feature set for the post-velar consonants is limited by the typological data.

Nevertheless, the specific phonetic realization of a phoneme can play a role in defining its phonological patterning. Examples include how the middle genioglossal contraction in Lak pharyngealized vowels allows those segments to palatalize velars and [lʲ] (Anderson 1997:974; Moisik 2013:482-486) and how the conditioned uvular allophones of /x/ and /n/ ([χ] and [ɴ]) in Filomeno Mata Totonac can become uvular and then lower vowels (§3.1.1; McFarland 2009:35-37). To allow phonology to have access to these facts, I propose that the allophones of phonemes, i.e. their actual realizations in specific languages, are associated with a finite set of phonetic subfeatures. Derivations can then reference these subfeatures, which allows non-contrastive, but categorical, aspects of phonetics to influence sound patterns. The relationship between features, phonetic subfeatures, allophones, and phonemes is presented schematically in Figure 4.9.

[20]I do not focus on questions about the innateness or cognitive reality of these features because these questions are beyond the scope of this dissertation. Briefly, I do not assume or propose here that these features are any more or less real in any cognitive or psychological sense than the contrasts that they are meant to capture.

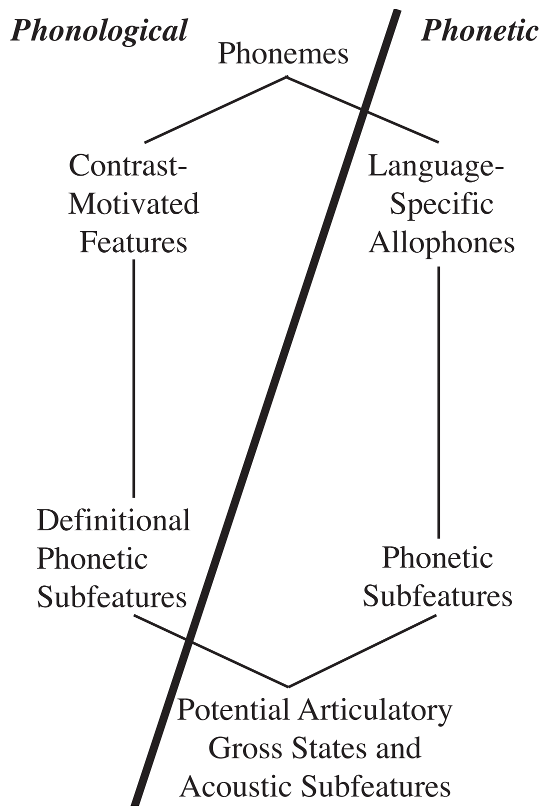


Figure 4.9: The direct association of phonemes with phonological features and indirect association of phonemes with phonetic subfeatures via language-specific allophones

Under this representational schema, phonemes can be represented formally either in terms of phonological features or as allophones. Phonetic subfeatures are associated both with phonological features and with allophones. Certain phonetic subfeatures are considered to be definitional of each phonological feature. This follows from the idea that although phonemic contrast is an abstract relationship, it is phonetically expressed. Phonetic subfeatures are associated with allophones by being characteristic of them. The content of phonetic subfeatures will be made more clear in §4.4.3.

Finally, it is also proposed that phonological features and phonetic subfeatures themselves should not be held responsible for predicting every phonological grouping of post-velar phonemes in sound patterns. The proposal for how phonological classes should be derived is discussed in detail in chapter 5.

In this chapter, the focus is on finding the set of phonological features that are required for establishing contrasts between the cross-linguistically attested post-velar consonants. Toward this end, the first subsections present the contrasts among post-velar phonemes according to high-level phonetic dimensions, including place of articulation (§4.4.1.1), possible secondary articulations (§4.4.1.2), phonation type (§4.4.1.3), and manner of articulation (§4.4.1.4). Each subsection presents the most elaborate contrasts that are observed to occur in a single language as well as all the other contrasts that are attested among post-velar consonants within a language. After presenting these contrasts, which play a fundamental role in determining the necessity of features, §4.4.2 presents the feature system used to capture the necessary contrasts. Finally, the phonetic subfeatures are presented in detail in §4.4.3.

### 4.4.1 Maximal and Attested Contrasts

One of the primary roles of features is to distinguish the phonemes of a given language. While there are many articulatory possibilities for producing post-velar consonants (Moisik 2013), relatively few appear to be used to contrast post-velar consonants as phonemes in any given language. Because the phonemic distinctions between post-velar phonemes are fewer than are theoretically possible given the articulatory possibilities for consonants articulated in that region, defining features using phonemic contrasts limits the proliferation of features that would occur if pure phonetic possibilities or groupings in phonological processes were used to motivate the feature set for the post-velar consonants. The post-velar phonemes appear to be phonemically distinguished in terms of place of articulation, secondary articulation, phonation type, and manner of articulation. These bases for distinguishing post-velar phonemes are reviewed below.[21]

#### 4.4.1.1 Place of Articulation

It is largely uncontroversial that velars contrast with uvulars, that uvulars contrast with pharyngeals, and that pharyngeals contrast with glottals. Moses-Columbia (Nxaʔamxcín; Salish) makes all these contrasts among its voiceless fricatives with the inventory /x, χ, ħ, h/, and Alutor (Chukotko-Kamchatkan) makes all these contrasts among its voiceless stops with the inventory /k, q, ʡ, ʔ/. This assumes that /ʡ/ fits into the IPA category "pharyngeal" even though it is usually described as epiglottal, which leads to the question of whether the pharyngeal and epiglottal places are distinct as the standard IPA categorization implies. In §4.4.2.1, it will be argued that these places are not distinct. For now, it suffices to say that sounds that have been described as pharyngeal or epiglottal stops appear to be made by constricting "the aryepiglottic folds—at the laryngeal sphincter mechanism [...] which seals the airway in an anterior movement against a descending tongue root" (Esling 1999:352-353). The tongue root itself is not the primary speech organ making the constriction. Instead, a sphincteric closure occurs at the aryepiglottic folds, and these "rise up and forwards to meet the base of the epiglottis rather than just the epiglottis retracting to cover the arytenoids" (Moisik 2013:68 citing Esling 1996). This phonetic description shows that there is no contrast between pharyngeal stops and epiglottal stops: Both are articulated with a sphincteric closure at the aryepiglottic folds.

Finally, while languages such as Alutor do seem to contrast an epiglottal stop with a uvular stop and a glottal stop, no language contrasts a pharyngeal stop with an epiglottal stop. Even Agul, which is claimed to make a phonemic contrast between pharyngeals and epiglottals (Ladefoged and Maddieson 1996:167-169) is only claimed to make the contrast among fricatives, not stops. It

[21]The full typology of attested post-velar consonants was summarized in §2.3.2.

will be shown in §4.4.2.1 that if this is a contrast in Agul, it is most likely not phonemic, and even if it were, it would be a distinction in manner rather than place (following Esling 1997, Heap 1997, and Moisik 2013).

To summarize, the maximal place distinction among post-velars is a three-way distinction between uvular, pharyngeal/epiglottal (a single category), and glottal.

#### 4.4.1.2 Secondary Articulations

The number of secondary articulation types available is greatest for uvulars (3), followed by glottals (2-3), and is lowest for pharyngeal/epiglottal consonants (1). In Moses-Columbia Salish (Nxaʔamxcín), the pharyngeal/epiglottal consonants /ʡ, ħ, ʕ/ all phonemically contrast with their labialized (rounded) counterparts /ʡ$^{w}$, ħ$^{w}$, ʕ$^{w}$/.[22]

The glottal consonants are able to bear labialization, as attested by /ʔ$^{w}$/ in Adyghe (Northwest Caucasian) and /h$^{w}$/ in Bagvalal (Nakh-Daghestanian). Khwarshi (Kwantlada dialect) is also claimed to contrast /h/ with pharyngealized /h$^{ʕ}$/. However, in the examples cited, it is unclear whether the /h$^{ʕ}$/ is an independent phoneme or whether it is /h/ bearing pharyngealization that is spread to it suprasegmentally.

Finally, the uvular consonants can bear labialization, pharyngealization, and palatalization. Unlike glottal or pharyngeal/epiglottal consonants, they can simultaneously bear two secondary articulations, labialization and pharyngealization. Ubykh exemplifies all these possibilities on its uvular stops and fricatives.

| *Base phoneme* | *Labialized* | *Pharyngealized* | *Palatalized* | *Labialized and Pharyngealized* |
|---|---|---|---|---|
| q | q$^{w}$ | q$^{ʕ}$ | q$^{j}$ | q$^{ʕw}$ |
| q’ | q$^{w}$’ | q$^{ʕ}$’ | q$^{j}$’ | q$^{ʕw}$’ |
| χ | χ$^{w}$ | χ$^{ʕ}$ | χ$^{j}$ | χ$^{ʕw}$ |
| ʁ | ʁ$^{w}$ | ʁ$^{ʕ}$ | ʁ$^{j}$ | ʁ$^{ʕw}$ |

Table 4.6: Uvular phonemes and their secondary articulations in Ubykh (Colarusso 1988:438)

Several gaps in the attestation of secondary articulations are important to note. First, no language, as far as I am aware, contrasts velarization with uvularization. This suggests that such an articulation might best be viewed as dorsalization since no finer phonological distinction appears to be necessary. Related to this is the uncertain status of uvularization as a secondary articulation. Studies attempting to find the articulatory correlates of emphasis in Arabic have variously called it velarization, uvularization, and pharyngealization. Opinions among researchers and findings

[22]In descriptive work on Moses-Columbia and other Interior Salish languages, the symbol /ʡ/ is not used. Instead, this phoneme is listed as /ʕ$^{ʔ}$/, a glottalized pharyngeal. This highlights the phonological patterning of /ʡ/ with the glottalized sonorants (resonants). However, through laryngoscopic examination, Carlson et al. (2004) found that /ʕ$^{ʔ}$/ is articulated as /ʡ/ in the related Interior Salish language Thompson (nɬeʔkepmxcín, Nlaka’pamux). Thompson allows labialization on this segment and /ʕ/, its only other pharyngeal/epiglottal consonant. It is assumed here that the articulation of this sound in Thompson and Moses-Columbia Salish is the same.

among dialects diverge, but it seems likely that at least one regular realization of emphasis in at least one dialect of Arabic can be classified definitively as uvularization. Uvularization, then, most likely exists phonetically, especially in the sense of it being an "upper pharyngeal" constriction, as is suggested in Czaykowska-Higgins (1987). However, no language appears to contrast uvularization and pharyngealization.[23] Relevant to the hypothesis that there is no place distinction between pharyngeal and epiglottal consonants is the fact that no language appears to contrast pharyngealization with epiglottalization. This fact points to viewing pharyngealization and epiglottalization as being a single phonological secondary articulation and provides supporting evidence for the view that there is no pharyngeal vs. epiglottal place distinction.

#### 4.4.1.3 Phonation Type

Among glottal and pharyngeal/epiglottal consonants, voicing is the only conventional phonation type that is used contrastively. In the Anatolian dialect of Abkhaz, /ħ/ "has been lowered to a laryngeal /h/" and this contrasts with /ɦ/ (Colarusso 1988:180,444). The glottal fricatives /h/ and /ɦ/ also contrast in the Changzhou (Changchow) dialect of Wu Chinese (Chao 1970). The pharyngeal/epiglottal consonants can also contrast in voicing. In Tashlhiyt Berber, the pharyngeal/epiglottal consonants /ʜ/ and /ʢ/ contrast primarily in terms of voicing (Ridouane 2003:148-163).

Unambiguous examples of this contrast with regard to the pharyngeal/epiglottal consonants is difficult to find given that trilling (a manner of articulation) and phonation can be difficult to separate, conceptually and empirically. Moisik (2013:93) notes that "many vocal structures can engage in self-sustaining oscillation" in which the structure "will continue to oscillate, overcoming its internal resistance, provided there is continuous energy input in the form of aerodynamic driving forces." Under this view, the vocal folds, aryepiglottic folds, uvula, tongue tip, and lips are all structures that can engage in self-sustaining oscillation. However, this self-sustaining oscillation at the vocal folds is referred to as phonation while at the other structures, it is termed trilling. Because the aryepiglottic folds are close to the vocal folds, are also part of the laryngeal structure, participate in vowel contrasts as "harsh voicing" in some languages (in an analogous way to creaky voicing, a phonation type), and seem to enhance consonant contrasts as trilling, it is difficult to determine whether aryepiglottic (or generally epilaryngeal) self-sustaining oscillation should be classified as phonation or trilling. The distinction between phonation and trilling in this case is primarily terminological, and this study avoids classifying self-sustaining oscillation of the aryepiglottic folds (or other epilaryngeal structures) one way or the other without reference to its function in a particular language or related group of contrasts.

[23] A possible exception is Ju|'hoansi, which Miller-Ockhuizen (2003) claims contrasts uvularized and epiglottalized consonants. Under the view advanced here that there is no pharyngeal vs. epiglottal place distinction, this would be a case in which uvularization and pharyngealization contrast. However, most researchers, for example Nakagawa (2006), view Miller-Ockhuizen's uvularized consonants as "clusters in which the cluster offset is an independent phoneme /χ/" (276). Under this view, termed the cluster analysis (250), Miller-Ockhuizen's epiglottalized consonants are clusters whose offset is an ejective uvular affricate [q͡χ'] (277). This study concurs with that point of view, and thus Ju|'hoansi is not a counterexample to the claim that uvularization and pharyngealization never contrast.

The phonation contrasts among uvular consonants also include voicing, but extend beyond it. For example, West !Xõo contrasts uvular stops according to voicing, aspiration, and ejection/glottalization.[24]

| *Phonation Type* | *Plain* | *Marked* |
|---:|---|---|
| Voicing | q | ɢ |
| Aspiration | q, ɢ | qʰ, ɢʱ |
| Ejection/Glottalization | q, ɢ | q’, ɢˀ |

Table 4.7: Phonation contrasts among uvular stops in West !Xõo (Naumann Forthcoming:4)

To summarize, the phonation contrasts that are necessary for post-velars overall, then, are voicing, aspiration, and ejection/glottalization.[25]

#### 4.4.1.4 Manner of Articulation

As was mentioned in the case of phonation type contrasts, the distinction between phonation and trilling, a manner of articulation, is not always easy to diagnose in the case of the pharyngeal/epiglottal place of articulation. Nevertheless, some clear cases emerge. For example, the only possible contrast between glottal phonemes is the manner contrast between a stop and fricative, and systems which contrast /ʔ/ and /h/ are very common (overwhelmingly more so than systems that use voicing to contrast /h/ and /ɦ/).

However, discussing the contrast between manners of articulation for pharyngeal/epiglottal consonants requires some background assumptions to be made clear. First, this study follows Esling (1997), Heap (1997), and Moisik (2013) in viewing the supposed contrast between pharyngeal and epiglottal consonants as a contrast not of place, but of manner. Under this view, the epiglottal stop [ʡ] is a pharyngeal/epiglottal stop, and the voiceless and voiced epiglottal fricatives [ʜ, ʢ], respectively, are instead pharyngeal/epiglottal trills. Several languages, including Iraqi Arabic, Somali, and Nuuchahnulth, are reported to use epilaryngeal trilling to phonetically enhance

---

[24]The voiceless stop contrasts as plain vs. ejective while the voiced stop contrasts as plain vs. post-glottalized.

[25]Another possible phonation contrast that is related to aspiration is that of tenseness in the Nakh-Daghestanian languages. These languages have stops that are variously called long, tense, fortis, or intensive. Tense stops are often pronounced as unaspirated in word-initial position, but are perceived as geminates in intervocalic position. This is most likely due to having a longer closure period than plain stops, since fricatives are also able to be tense, in which case tenseness is realized as extra duration rather than as aspiration. While this might lead to the interpretation of all tense consonants as geminates, tense consonants are said to be perceptually distinct from true gemination in Tsova-Tush according to native speaker judgements. Holisky and Gagua (1994:151) write, about the tense consonants, that “according to Gagua [a native speaker of Tsova-Tush; JCS] they differ acoustically from clusters which arise at morpheme boundaries. For example, the two /s/’s in *oqus-sa*ⁿ ‘like him’, are distinct from /s:/, as in *is:* ‘nine’.” Because of this judgement and similar claims made for other languages, tenseness might be thought of as an additional dimension of phonation contrast between uvular (and more anterior) consonants. However, under this interpretation, tenseness may be thought of as a dimension of aspiration. If tense consonants are really geminate, then tenseness is not a phonation type.

phonemes traditionally described as pharyngeal (/ħ, ʕ/) (Moisik 2013:104). Thus, the only manner distinction in the pharyngeal/epiglottal place is that between a stop and fricative, which is attested in Chechen and Ingush: the voiceless stop /ʡ/ contrasts with the voiceless fricative /ħ/.

The manner contrast between stops and fricatives is also the only solidly attested manner distinction among uvulars. For example, as shown in Table 4.6, the voiceless stop /q/ and the voiceless fricative /χ/ fully contrast in Ubykh among both the plain variants and the variants with each kind of secondary articulation. Other contrasts among the uvulars may be possible, but they are not as certainly attested. For example, the dorsal nasal in Klallam as well as in Iwellemeden and Ayr Berber (both spoken in Niger) is described as uvular. However, as far as the author is aware, no language contrasts a velar and uvular nasal. In Kalaallisut (West Greenlandic Eskimo), Fortescue (1984:333-334) reports the existence of a velar nasal and a uvular nasal, but notes that the uvular nasal only occurs as an allophone of /q/ and as a geminate "as a reflex of original */nʁ/ or */mʁ/" ('r' in source normalized to IPA [ʁ]; JCS). Furthermore, the uvular nasal, as a geminate, is interpreted by Sadock (2003:20) as being phonologically /ʁ + ŋ/, which is reflected in the orthography by writing the uvular nasal as 'rng'. Sadock writes that "[p]honetically, a cluster beginning with a uvular is a geminate version of the second consonant [/ŋ/; JCS] with uvular coloring of the preceding vowel" (ibid.). This uvular coloring is usually interpreted as pharyngealization (Gallagher 2007; Bobaljik 1996). Finally, if affrication is considered to be a manner contrast, then it contrasts with the plosive (stop) manner in G|ui (Nakagawa 2006:109,122-127) where /q'/ contrasts with /q͡χ'/.[26]

In sum, all the post-velar consonants can contrast the stop and fricative manners. Pharyngeal/epiglottal consonants may also be able to use the trill manner contrastively. Uvular consonants can be distinguished in terms of plain vs. affricated, and may be able to be distinguished by being nasal, although it is not clear that a uvular nasal ever phonologically contrasts with a velar nasal.

#### 4.4.1.5 Summary of Maximal and Attested Contrasts Among Post-Velar Consonants

Table 4.8 provides an overview of the attested contrasts among post-velar consonants. The header row reflects the finding that the maximal post-velar place contrast is between uvular, pharyngeal/epiglottal, and glottal.

[26] In addition, even though uvular trills are attested in a number of languages, no language surveyed here contrasts it with another uvular consonant.

| | | *Uvular* | *Pharyngeal/Epiglottal* | *Glottal* |
|---|---|---|---|---|
| *Secondary* | labialization | ✓ | ✓ | ✓ |
| *Articulations* | pharyngealization | ✓ | | (✓) |
| | palatalization | ✓ | | |
| | lab. & phar. | ✓ | | |
| *Manner of* | stop | ✓ | ✓ | ✓ |
| *Articulation* | fricative | ✓ | ✓ | ✓ |
| | affricate | ✓ | | |
| *Phonation* | voicing | ✓ | ✓ | ✓ |
| *Type* | aspiration | ✓ | | |
| | ejection/glottalization | ✓ | | |

Table 4.8: Overview of attested phonemic contrasts among post-velar consonants

## 4.4.2 Phonological Features of Post-Velar Consonants

### 4.4.2.1 Place of Articulation

This study follows Esling (1997), Heap (1997), and Moisik (2013) in arguing that the IPA's categories pharyngeal and epiglottal are never phonemically distinctive and can instead be thought of as a single place of articulation, pharyngeal/epiglottal. This goes against the prominent hypothesis of Ladefoged and Maddieson (1996:167-169) that pharyngeal and epiglottal fricatives are phonemically distinctive in the Burkikhan dialect of Agul. There is reason to doubt not only the place distinction, but even the phonemic distinction.

First, the data cited in Ladefoged and Maddieson (1996) exhibit only near-minimal pairs. This cannot be taken as proof that the consonants are not phonemically opposed, but it leaves the contrast open for questioning. Only certain dialects are claimed to contrast pharyngeal and epiglottal phonemes (namely Buršč̌ag, Riča, Burkikhan, but not Fite; Kibrik and Kodzasov 1990:338-341). The contrast also does not exist in the Huppuq' dialect, and recent field research on Burkikhan failed to confirm the presence of the pharyngeal vs. epiglottal contrast there (Timur Maisak, p.c.). It is unclear without current articulatory examination whether the consonants in Agul that were termed "epiglottal" by Ladefoged and Maddieson (1996) are phonemically contrastive, even in manner, from the consonants that were termed "pharyngeal." It is for this reason that Agul is not taken to be an example of a language in which the trill manner of articulation is contrastive from the fricative manner.

Phonetic evidence supports the idea that the distinctions between consonants in Agul that are attributed to place differences by Ladefoged and Maddieson (1996) can instead be attributed to distinctions in manner (Esling 1997:8-9; Heap 1997:18-19; Moisik 2013:119-138). Specifically, Moisik (2013:119-138) shows that what are described as epiglottal fricatives by Ladefoged and Maddieson (1996) often involve "conspicuous amplitude modulation[s]" that are similar to those found in unambiguous tokens of aryepiglottal vibration, which is a form of epilaryngeal vibration and is a form of trilling.[27] This strongly suggests that some form of epilaryngeal trilling is taking place. This provides reasonable evidence for reinterpreting the so-called "epiglottal" fricatives (/ʜ/ and /ʢ/) as instead being trills whose place of articulation is not distinctive from that of the conventional pharyngeal fricatives (/ħ/ and /ʕ/). The distinction between epiglottal and pharyngeal consonants is actually a distinction in manner rather than place. This reconceptualization of the contrast in these sounds calls for a revision of the traditional IPA pharyngeal consonants as shown below (based on Esling 2010:696).

| | Pharyngeal-Epiglottal | |
|---|---|---|
| Plosive | ʡ | |
| Nasal | | |
| Trill | ʜ | ʢ |
| Tap or Flap | | |
| Fricative | ħ | ʕ |
| Lat. Fric. | | |
| Approximant | | ʕ |
| Lat. Approx. | | |

Table 4.9: A reconceptualization of the IPA's pharyngeal place based on evidence that the pharyngeal/epiglottal distinction is one of manner, not of place (based on Esling 2010:696, Figure 18.6)

To fully understand the idea that the pharyngeal and epiglottal places are not phonologically distinct, the anatomy of the lower vocal tract must be briefly discussed.[28] The *lower vocal tract* is understood here to be a region of the vocal tract that "is bounded inferiorly by the glottis and superiorly by the oropharyngeal isthmus and velo-pharyngeal port" Moisik (2013:84). Sounds articulated in this area are here termed *post-velar*. The view of the composition of the lower vocal tract among many linguists (and which is embodied in the IPA) is that there is the glottis, above which is a large area, the pharynx, into which the tongue can protrude, and above that is the uvula. This view neglects the complexity of the larynx, which includes not only the glottis but a set of anatomical structures that comprise the epilarynx. It is worth discussing in turn how each common phonological definition diverges from the articulatory phonetic definitions.

The glottis is assumed to behave semi-independently from the rest of the consonants, and this view is supported by the existence of processes in which the glottal features seem to pattern together to the exclusion of all other features. An example of this is debuccalization in Caribbean Spanish in which /s/ in syllable coda position becomes [h]. In debuccalization, only glottal features are retained; all other features are deleted. The opposite of this process, in which only glottal features are deleted and all other features are retained, also occurs. Clements (1985:235) (quoted

[27]These tokens are shown in Figure 3.9 of Moisik (2013:121).

[28]The discussion that follows is heavily indebted to Moisik (2013) whose work has clarified the articulatory aspects of sounds that have been termed pharyngeal, epiglottal, guttural, post-velar, retracted, harsh, etc.

in Sagey 1990:29) writes that "in Klamath, a three-way contrast among voiced, voiceless, and glottalised obstruents is neutralised immediately preceding another stop [...]." In this case, the glottal features of obstruents are deleted, but all other features are retained. Feature geometries account for this independence by positing a Laryngeal node, which dominates all the glottal features, and by keeping this node separated from the Place node, which dominates the Labial, Coronal, and Dorsal nodes and their features. The Laryngeal node is usually linked only to the Root node (or what can be understood as the Root node in feature geometries such as that of Halle (1995) that formally lack a Root node). Because the glottal features are typically dominated by the Laryngeal node, they are usually called laryngeal features. In this view, the larynx is functionally synonymous with the glottis, and thus Moisik (2013:65) calls this the *glottocentric* view.

The pharyngeal consonants are typically assumed to be consonants articulated by retracting the root of the tongue toward the posterior wall of the pharynx. Under this view, the tongue, specifically the tongue root or radix, is the active articulator while the pharynx is the passive articulator as well as the place of articulation. While it has been observed at least since the work of Catford (1977a:163) that pharyngeal consonants can involve active articulation from anatomical structures other than the tongue root, the view of the pharyngeal consonants as being essentially tongue root consonants has become standard.[29] This standard view is termed *linguocentrism* by Moisik (2013:65).

In comparison to the glottal and pharyngeal consonants which have standardized definitions and have been argued to have certain formal representations in phonology, the epiglottal consonants have been largely neglected. There are many reasons for this. First, it is difficult to distinguish epiglottal consonants from pharyngeal consonants, and the only widely known sources to advocate a distinction are Laufer and Condax (1981) and Ladefoged and Maddieson (1996).[30] Invasive articulatory techniques such as fibroscopy, which are in general seldom used, provide the surest means to conclusively show that a sound is articulated with the epiglottis, and this is another reason why very few sounds are described as epiglottal. Another primary reason, possibly a consequence of the first, is that there are no canonical examples of epiglottal (as opposed to pharyngeal) consonants. Many languages exemplify the glottal consonants (especially /h, ʔ/) and Arabic, which is widely spoken and generally well-known, provides a canonical example of pharyngeals. However, the only language that comes close to providing canonical examples of an epiglottal consonant is Agul. Finally, Agul is the only language that has been proposed to make a phonemic distinction between pharyngeals and epiglottals.

[29]In fact, this view is so widely held and so frequently taught that pharyngeal consonants are often described as being articulated this way in primary language descriptions based on field work even though no articulatory investigation was actually done. Researchers should be very skeptical of pharyngeal/epiglottal consonants that are described as being articulated in this way. The description should not be taken at face value without articulatory evidence, but should instead be seen as a ripe opportunity for articulatory investigation, for example by imaging techniques such as laryngoscopy or laryngeal ultrasound.

[30]Laufer and Condax (1981) were the first to discuss a possible role for the epiglottis in speech, and they claimed on the basis of fibroscopic evidence that the epiglottis was able to function independently from the tongue root as an active articulator in Eastern (Oriental) Hebrew. Although later work by Laufer and Baer (1988) found no evidence to support this position (or refute it), the view of the epiglottis as a possible independent articulator still holds sway.

To argue against the standard conceptions of glottal, pharyngeal, and epiglottal consonants and progress beyond them, it is necessary to define the unified pharyngeal/epiglottal place, whose members are schematically presented in Table 4.9. In terms of anatomy, the pharyngeal/epiglottal place includes the tongue root, the pharynx, and the epilarynx. The tongue root is the part of the tongue that extends up from a connection with the base of the epiglottis to where the tongue dorsum begins, which is slightly lower than the position of the uvula. The epilarynx is a tube structure "nested within and independent from the enclosing pharyngeal tube" which contains "the ventricular folds, aryepiglottic folds, epiglottis, and arytenoid cartilage complex" (Moisik 2013:26-27). These structures can be seen in the drawing in Figure 4.10 from Moisik (2013:20).

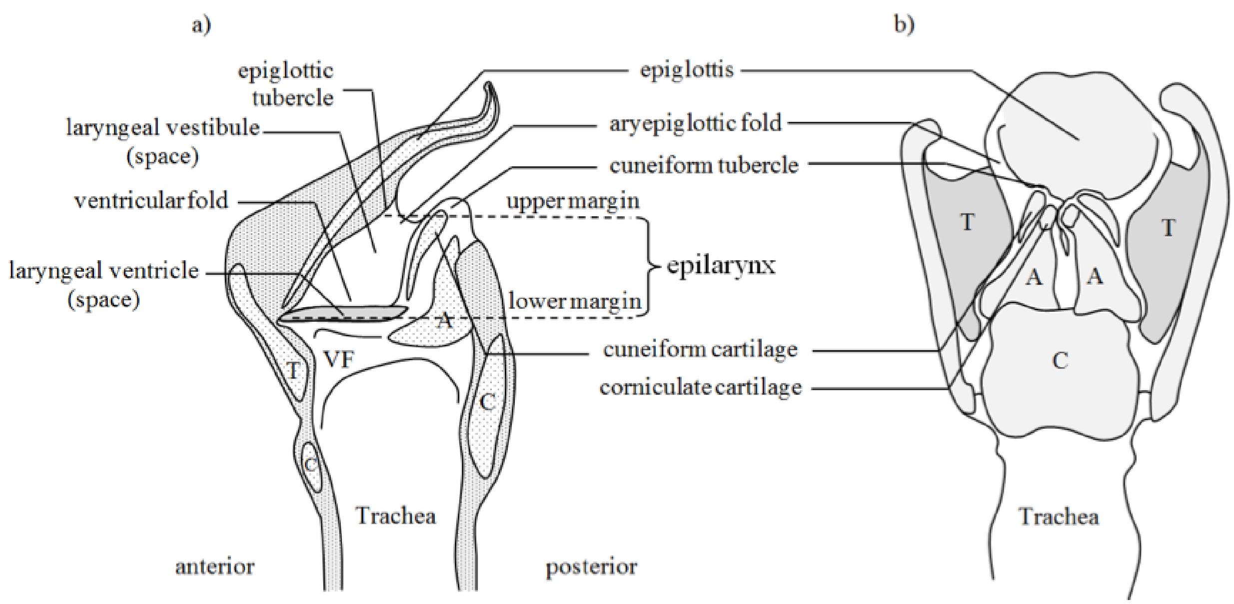


Figure 4.10: Figure 2.2 of Moisik (2013:20; used with permission). Schematic view of the larynx illustrating structures involved in the definition of the epilarynx. The illustration on the left is a mid-sagittal section while the illustration on the right is the interior of the larynx from a posterior point of view. Abbreviations: A = arytenoid cartilage, C = cricoid cartilage, T = thyroid cartilage, VF = vocal fold.

Under this conception of the pharyngeal/epiglottal place, the tongue dorsum remains distinct, as does the glottis (and vocal folds).

The epilarynx is a complex set of structures which are able to interact with other speech organs. Two of the most important connections are that of 1) the lower epilarynx, including the ventricular folds, with the glottis and vocal folds, and 2) the upper epilarynx, including the aryepiglottic folds and epiglottis, with the tongue root. The upper and lower regions of the epilarynx are physiologically continuous with no obvious anatomical division (Moisik 2013:27). Beyond these connections, activity of the structures of the epilarynx provide phonetic explanations for a wide range of phonological behavior, including some that is as yet unattested.

One of the main problems with current featural representations of pharyngeal/epiglottal consonants is that the features capture an inherently linguocentric view of their articulation when the active articulator appears to be the epilarynx. The featural representation of pharyngeal/epiglottal consonants relies heavily on the assumption that retraction of the tongue root is the active articulation that produces them. For example, the featural representations for post-velar consonants in Rose (1996:80) mostly uses non-terminal Feature Geometric nodes, especially Dorsal and Pharyngeal. The only terminal feature that it uses to model classes of post-velars is [Retracted Tongue Root] ([RTR]). Rose (1996:80) explicitly states that "the feature [RTR] characterises all non-laryngeal gutturals, since uvulars, pharyngeals and emphatics all involve retracting the tongue root or constricting the pharynx in their production."

To get rid of the linguocentric bias in featural representation, this study proposes using the feature [±constricted epilarynx], or [±ce] for short, to distinguish pharyngeal/epiglottal consonants and the secondary articulations that are conventionally called pharyngealization or epiglottalization. This feature improves on the feature [±low] in that it has a clear physiological basis and articulatory studies (by John Esling, Scott Moisik, and others) have shown the epilarynx to be an active articulator. The feature [±constricted epilarynx] is based on a similar feature, [±constricted epilarynx tube] ([±cet]) proposed in Moisik and Esling (2011).

(74) *Definition of the feature* [±ce]:
A phoneme whose primary realization involves a constriction of a structure in the epilarynx (e.g. the aryepiglottic folds) is [+ce].

To more accurately characterize the articulation of non-coronal, non-anterior consonants that are articulated with the tongue, I propose using features inspired by Esling's (2005) discussion of vowel articulation. Esling (2005:19) provides three descriptors – 'front,' 'raised,' and 'retracted' – that correspond to "three directions of lingual movement[,]" which "are attributable to the three major extrinsic lingual muscle groups: the genioglossus, the styloglossus, and the hyoglossus[,]" respectively. This study makes use of those descriptors as binary features to describe lingual articulations, and these features replace the traditional features [±high, ±low, ±back] for use with consonants. These traditional features are now understood to match acoustics better than articulation.[31] To see how the articulatory features being proposed divide the vowel space in comparison to the traditional acoustic features, see Figure 4.11.

[31] Because evaluating the impact of ceasing to use these features to describe vowels is beyond the scope of this dissertation, it is assumed that vowels can use both these acoustic features and the articulatory features being proposed.

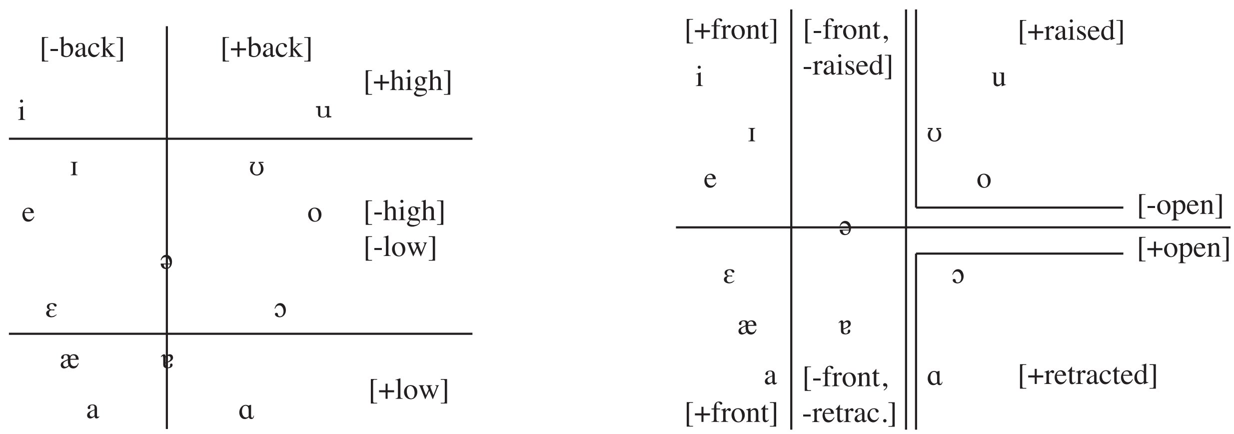


Figure 4.11: Vowel space divided according to traditional acoustic features (left) and according to the articulatory description in Esling 2005 (right)

The feature [+raised] is used to characterize uvulars and velars and is thus similar to more familiar [Dorsal].

(75) *Definition of the feature* [±raised]:
A phoneme whose primary realization involves movement of the tongue by the styloglossus upward and backward, relative to a standard mid-sagittal section, is [+raised].

The feature [+front] captures movement of the tongue body forward by the genioglossus. This feature is used to capture palatals and palatalization.

(76) *Definition of the feature* [±front]:
A phoneme whose primary realization involves forward movement of the tongue body by the genioglossus, relative to a standard mid-sagittal section, is [+front].

The feature [+retracted] is used to describe any articulation in which the tongue body is obligatorily retracted. Because only epilaryngeal constriction, not tongue body retraction, is obligatory in articulating pharyngeals, this feature is not used to describe pharyngeal consonants.

(77) *Definition of the feature* [±retracted]:
A phoneme whose primary realization involves retraction of the tongue body by the hyoglossus is [+retracted].

By defining this feature as retraction of the tongue *body*, not root, it is distinct from the feature [RTR] (Retracted Tongue Root), which plays a role in vowel harmony systems.[32] The final articulatory feature that is necessary for describing post-velar consonants is [±open], which refers to jaw openness Esling (2005:18).

(78) *Definition of the feature* [±open]:
A phoneme whose primary realization involves a relatively open jaw position is [±open].

[32]Because this dissertation is concerned primarily with post-velar consonants, the question of the degree to which [±retracted] and [±RTR] are separately needed is left for future research.

Uvulars and pharyngeals are associated with jaw openness, but jaw openness is irrelevant for glottal consonants.[33]

With these features defined, the proposed featural representation for all the non-coronal, non-anterior places of articulation is provided in the table below.

| | Palatal | Velar | Uvular | Phar./Epi. | Glottal |
|---|---|---|---|---|---|
| [*front*] | + | - | - | - | - |
| [*raised*] | - | + | + | - | - |
| [*open*] | - | - | + | + | - |
| [*ce*] | - | - | - | + | - |

Table 4.10: The featural representation for phonemes with a non-coronal, non-anterior place of articulation

This featural representation is a better match with articulatory facts than a representation in which the more acoustic vowel features [±high, ±low, ±back] are used. Other predictions and benefits of this representation will be made clear when secondary articulations are considered.

#### 4.4.2.2 Secondary Articulations

Secondary articulations can be represented by copying the positively valued lingual feature that characterizes each non-anterior, non-coronal place of articulation, as seen in Table 4.10. This means that palatalization entails adding the feature [+front] and pharyngealization/epiglottalization means adding the feature [+ce]. The feature [+round] is retained for representing labialization. The feature [+raised] can be added to signal a secondary dorsal articulation. As far as the author is aware, no language phonologically distinguishes velarization from uvularization. Thus, both of these can be phonologically modeled as ‘dorsalization.’ Because [+raised] characterizes dorsals, it can be used to signal dorsalization.

This system of representing secondary articulations and place of articulation among the non-coronal, non-anterior consonant phonemes allows for the representation of palatalization and pharyngealization on any place of articulation, since [+front] is uniquely palatal and [+ce] is uniquely pharyngeal/epiglottal. Palatalized uvulars, which are problematic for the feature theory of SPE, are represented as [+raised, +front, +open]. Palatalized velars are distinct from these by virtue of their [-open] feature. The feature system that I propose here does predict, though, that palatalized velars and velarized palatals will never be phonologically distinct.

The similarly problematic pharyngealized uvulars are represented as [+raised, +ce]. Pharyngealized uvulars were problematic for SPE because they had to be represented as [+back, +low], which was the exact representation for pharyngeals. Using [±ce] allows pharyngealized uvulars

[33]An unfortunate by-product of specifying glottals as [-open] is that they might be expected to pattern with other consonants or vowels that share this feature, which is not observed as far as the author is aware. It would be best if this feature could be left unspecified for glottal consonants.

to be [+raised, +ce] while regular pharyngeal/epiglottal consonants are [-raised, +ce]. Pharyngealized uvulars and pharyngealized velars can be distinct in the same way that the palatalized versions of these consonants are distinct, which is by means of their openness feature. Representing pharyngeal/epiglottal place with [+ce] instead of [+low] also allows vowels to be pharyngealized/epiglottalized using the same featural specification that is used for consonants. It also allows [+low] vowels to be contrastively pharyngealized using that same feature. This is beneficial because some languages are able to contrastively pharyngealize every vowel quality (e.g. Even [Tungusic; Aralova et al. 2011]), notably in ways that seem definitely not to involve the better-known [±RTR] feature (e.g. Lak [Nakh-Daghestanian; Catford 1977b]).

The featural representation that I propose here avoids the descriptive problems encountered by the SPE system by proposing additional phonologically-motivated features that ensure that even with an unstructured featural representation of phonemes, the featural specifications of phonemes will not overlap and contrast will be maintained. However, the method for specifying a secondary articulation on a phoneme is the same as in SPE, and this is inadequate for explaining the differing phonological behavior of primary and secondary articulations. For example, secondary articulations like pharyngealization or uvularization are able to spread at a distance, and in CV harmony systems, like pharyngealization spreading in Azerbaijani Jewish Aramaic (§3.2.1), secondary articulations can spread across both consonants and vowels. Ultimately, a representation that distinguishes primary from secondary articulations is necessary. One framework that does this is Davis' (1995:469-472) representational system, which proposes that segments have 1-place (primary articulation) and 2-place (secondary articulation) features. In this proposal, the phonetic motivation behind the distinction could be a difference in degree of constriction, with 2-place represented by an approximant-like constriction (or one that is even weaker). Another proposal, by Ní Chiosáin and Padgett (1993), splits these into consonant place (C-place; primary articulation on consonants) and vowel place (V-place; secondary on consonants, primary on vowels). Either of these proposals would achieve the effect of distinguishing primary from secondary articulation, and would need to be disambiguated on the basis of other evidence.[34]

#### 4.4.2.3 Phonation Type

The phonation contrasts among post-velar consonant phonemes are maximally distinctions in voicing, aspiration, and ejection/glottalization. This study uses [±voiced] ([±voi]) to distinguish voiced consonants from voiceless ones. It also uses [+spread glottis] ([+sg]) for /h/ and aspirated phonemes. It uses [+constricted glottis] ([+cg]) for /ʔ/ and ejection/glottalization. Segments cannot be simultaneously [+cg, +sg], but [-cg, -sg] is used for modal phonation (Hayes 2009). The features [±cg] and [±sg] allow pharyngealized/epiglottalized glottals (such as /hˤ/ reported for Khwarshi) to be kept distinct from plain pharyngeal/epiglottal consonants.

[34]See Halle et al. (2000) for discussion comparing various proposals for disambiguating primary and secondary place.

#### 4.4.2.4 Manner of Articulation

The post-velar consonants are phonemically distinguished in terms of manner by the distinction between stops, fricatives, and affricates. The feature [±continuant] ([±cont]) is used to distinguish stops and fricatives. Affricates, however, are assumed to use a non-linear mode of representation such that they need not be distinguished from stops and fricatives using features. Such a non-linear representation would be like that offered in Sagey (1990:52), except that the featural specifications would be linked to a skeletal node (e.g. C) rather than to a non-terminal Feature Geometric node.

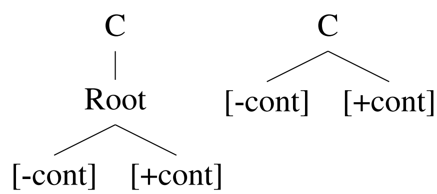


Figure 4.12: Non-linear representation for affricates. The representation on the left is adapted from Sagey (1990:52) while the one on the right is the modified version used in this study.

#### 4.4.2.5 Featural Specifications for All Post-Velar Consonant Phonemes

A significant new feature proposed here is [±ce], defined in (74) and based on [±cet], a similar feature proposed by Moisik and Esling (2011). Other new features include the articulatory features based on descriptions of lingual movement given by Esling (2005). These features include [±front, ±raised, ±retracted]. Another feature, [±open], is used to model jaw openness. The other features used to contrast the post-velar consonant phonemes were adapted from well-known features in Halle (1995:2). One departure from Halle (1995) is the use of the feature [±voice] rather than the features [±stiff vocal folds] and [±slack vocal folds].

The following table shows the featural specification for all the post-velar consonant phonemes that were recorded in §2.3.2 as the overall results of the typological survey done in this study. With reference to the tables in §2.3.2, the consonants are presented from the first table to the last, starting in each table with the base consonant and proceeding top to bottom and left to right. The consonants from each table in §2.3.2 are divided by a horizontal line for ease of comparison.

Tense consonants from the Nakh-Daghestanian languages are not included since the exact nature of the tenseness distinction is unclear (it could be aspiration, true gemination, or a hybrid, e.g. unaspirated geminates). The prenasalized uvular stop is not included here since its featural representation will uncontroversially involve a specification for nasality (e.g. [+nasal]). Finally, affricates are not included in this table since they can also be captured by a non-linear representation. The prenasalized uvular could also be captured this way.

| **C** | [*round*] | [*front*] | [*raised*] | [*open*] | [*ce*] | [*cg*] | [*sg*] | [*cont*] | [*voi*] |
|---|---|---|---|---|---|---|---|---|---|
| *q* | - | - | + | + | - | - | - | - | - |
| $q^{w}$ | + | - | + | + | - | - | - | - | - |
| $q^{j}$ | - | + | + | + | - | - | - | - | - |
| *q*$^{ʕ}$ | - | - | + | + | + | - | - | - | - |
| *q*$^{ʕw}$ | + | - | + | + | + | - | - | - | - |
| $q^{h}$ | - | - | + | + | - | - | + | - | - |
| $q^{hw}$ | + | - | + | + | - | - | + | - | - |
| *q'* | - | - | + | + | - | + | - | - | - |
| *q'*$^{w}$ | + | - | + | + | - | + | - | - | - |
| *q'*$^{j}$ | - | + | + | + | - | + | - | - | - |
| *q'*$^{ʕ}$ | - | - | + | + | + | + | - | - | - |
| *q'*$^{ʕw}$ | + | - | + | + | + | + | - | - | - |
| ɢ | - | - | + | + | - | - | - | - | + |
| ɢ$^{w}$ | + | - | + | + | - | - | - | - | + |
| ɢ$^{ʕ}$ | - | - | + | + | + | - | - | - | + |
| ɢ$^{ʕw}$ | + | - | + | + | + | - | - | - | + |
| ɢ$^{ɦ}$ | - | - | + | + | - | - | + | - | + |
| ɢ$^{ʔ}$ | - | - | + | + | - | + | - | - | + |
| $\chi$ | - | - | + | + | - | - | - | + | - |
| $\chi^{w}$ | + | - | + | + | - | - | - | + | - |
| $\chi^{j}$ | - | + | + | + | - | - | - | + | - |
| $\chi$$^{ʕ}$ | - | - | + | + | + | - | - | + | - |
| $\chi$$^{ʕw}$ | + | - | + | + | + | - | - | + | - |
| ʁ | - | - | + | + | - | - | - | + | + |
| ʁ$^{w}$ | + | - | + | + | - | - | - | + | + |
| ʁ$^{j}$ | - | + | + | + | - | - | - | + | + |
| ʁ$^{ʕ}$ | - | - | + | + | + | - | - | + | + |
| ʁ$^{ʕw}$ | + | - | + | + | + | - | - | + | + |
| ʀ[35] | - | - | + | + | - | - | - | + | + |
| ħ | - | - | - | + | + | - | - | + | - |
| ħ$^{w}$ | + | - | - | + | + | - | - | + | - |
| ʕ | - | - | - | + | + | - | - | + | + |
| ʕ$^{w}$ | + | - | - | + | + | - | - | + | + |
| ʡ | - | - | - | + | + | - | - | - | - |

[35]This sound, a trill, must be distinguished from the voiced uvular fricative by a general feature that designates trills. One possibility is the feature [±flap], whose positive value would indicate trills (Hall 1997:119-120).

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| *ʡ*$^w$ | + | - | - | + | + | - | - | - | - |
| *ʔ* | - | - | - | - | - | + | - | - | - |
| *ʔ*$^w$ | + | - | - | - | - | + | - | - | - |
| *h* | - | - | - | - | - | - | + | + | - |
| *h*$^w$ | + | - | - | - | - | - | + | + | - |
| *h*$^ʕ$ | - | - | - | - | + | - | + | + | - |
| *ɦ* | - | - | - | - | - | - | + | + | + |

Table 4.11: The featural specification advocated here for characterizing post-velar consonantal phonemes

### 4.4.3 Phonetic Subfeatures of Post-Velar Consonants

The phonological features proposed above are meant to account for every possible cross-linguistic phonemic contrast. They are not meant to account for patterns in how phonemes cluster together as phonological classes in sound patterns (i.e. phonological processes and distributional constraints). Chapter 5 proposes a solution to the challenge of accounting for phonological class behavior. The phonological features proposed above are also not meant to provide an exhaustive phonetic description of each phoneme although they are meant to be as phonetically accurate as possible in describing the dimension of contrast. It was argued before that trying to provide an exhaustive phonetic description of phonemes using phonological features would eliminate one of the main purposes of those features (namely to abstract over phonetic variation) and would also lead to a proliferation of highly specific features that may only be used for very few languages.

However, as was mentioned in §4.4, the phonetic realization of phonemes can affect their phonological patterning. Recall that because pharyngealized vowels in Lak are articulated with a "double bunching" articulation that includes both anterior (palatal) and posterior (pharyngeal) lingual constrictions, these vowels condition palatalization on adjacent velars and /l/ (Anderson 1997:974; Moisik 2013:482-486). This process can be explained as the transfer of the anterior articulation of the pharyngealized vowels onto susceptible segments, namely the velars and /l/. The problem is that under the feature system proposed above (as well as every other featural representation proposed in the available literature), derivations have no way of formally referring to this articulatory detail. Thus, while the phonological effects of pharyngealized vowels in Lak have a straightforward articulatory explanation, there is no way for the formal phonology to use this explanation. To incorporate insights like this from phonetics into phonology, I propose linking phonetic subfeatures to the allophones of a language's phonemes.

The need for recognizing regularly realized phonetic features that are not the basis of phonemic contrasts, but are nevertheless phonologically relevant, has been recognized before. Kiparsky (1995) calls these "quasi-distinctive" features, and notes that when the conditioning environment that causes the appearance of these features is lost, the features transition from being quasi-distinctive to being fully distinctive. An example of this is the loss of the velar-uvular distinction creating phonemically contrastive high and mid vowels in Cochabamba Quechua described in §3.1.1. Phonetic subfeatures have also been used to derive similarity thresholds in harmony processes (Wayment 2009:96; Lionnet 2014).

The phonetic subfeatures that I propose here take the form of gross physiological states, such as {**tre**} "tongue retraction" (as defined in Moisik 2013:374-388), as well as acoustic descriptions, such as {**hF1**} "high F1."[36] Gross physiological states, or gross states for short, are "general [articulatory] configurations or postures of the vocal tract" that "may be static or involve dynamic behaviour" (Moisik 2013:374). These gross states can be characterized in terms of muscle action, articulator position, and airflow (for these more detailed descriptions, see Moisik 2013:375). The gross physiological states sketched by Moisik (2013:375) to describe articulations in the lower vocal tract are presented in Table 4.12, with the addition of a gross state {**lro**} to describe lip rounding. These are followed by a table showing the acoustic phonetic subfeatures that are related to formant values.

| *Gross State* | *Physiological Description* |
|---|---|
| {**dbe**} | double bunching epilaryngeal configuration (as in Lak pharyngealized vowels) |
| {**epc**} | epilaryngeal constriction |
| {**epv**} | epilaryngeal vibration |
| {**llx**} | lowered larynx |
| {**lro**} | lips rounded |
| {**rlx**} | raised larynx |
| {**tdb**} | tongue double bunching (as in American /ɹ/) |
| {**tfr**} | tongue fronting |
| {**tra**} | tongue raising (up and back) |
| {**tre**} | tongue retraction (down and back) |
| {**vfc**} | vocal folds close (adducted; as for aspirated stops) |
| {**vfo**} | vocal folds open (abducted; as for ejectives) |
| {**vfv**} | vocal fold vibration |
| {**vtc**} | anterior vocal tract relatively closed, jaw raised from neutral open position |
| {**vto**} | anterior vocal tract relatively open, jaw lowered from neutral open position |

Table 4.12: Gross physiological states to describe sounds articulated in the lower vocal tract, following Moisik (2013:375, Table 6.7).

[36]By the convention established in (Moisik 2013), gross states are contained in curly braces ( { } ) and are labeled in bold.

| *Acoustic Subfeature* | *Description* |
|---|---|
| {**lF1**} | relatively low F1 |
| {**hF1**} | relatively high F1 |
| {**lF2**} | relatively low F2 |
| {**hF2**} | relatively high F2 |
| {**lF3**} | relatively low F3 |
| {**hF3**} | relatively high F3 |

Table 4.13: Acoustic phonetic subfeatures related to formant frequencies

These phonetic subfeatures, which include both gross states and acoustic subfeatures, are associated with phonemes through both phonological features and their allophones. Phonemes can be described in terms of both phonological features and in terms of their language-specific allophones. Phonological features are considered to have gross states or acoustic subfeatures that are definitional of those features. For example, for [+cg], both {**rlx**} and {**vfc**} are considered definitional since glottal constriction involves both closing of the vocal folds ({**vfc**}) and raising of the larynx ({**rlx**}), as in ejectives. The phonetic subfeatures that are considered to partially define phonological features are shown in Table 4.14.[37]

| Phonological Feature | Phonetic Subfeature |
|---|---|
| [±round] | {**lro**} |
| [±front] | {**tfr**} |
| [±raised] | {**tra**} |
| [±open] | {**vto**} |
| [±constricted epilarynx] | {**epc**} |
| [±constricted glottis] | {**rlx**, **vfc**} |
| [±spread glottis] | {**vfo**} |
| [±voiced] | {**vfv**} |

Table 4.14: Phonological features and the phonetic subfeatures that partially define them

Allophones, which are necessarily language-specific, are associated with the phonetic subfeatures that characterize their articulation. This means that while certain phonetic subfeatures are related to phonological features by partly defining them, they are associated with allophones because those allophones actively use certain articulations and produce certain acoustic effects. These separate associations allow formal features to interface with actual phonetic content and at

[37]The feature [±continuant] is omitted from this table. It is unclear what the exact phonetic subfeature that should be associated with this is, and this particular definitional relationship is not crucial for any of the derivations in this study.

the same time allow language-specific phonetic characteristics of the allophones of phonemes to be a part of phonological derivations.

One example of the need for allowing phonology to access the phonetic traits of language-specific allophones is the differential patterning of /q/ and uvular fricatives in Arabic.[38] This differential phonological behavior occurs only in Semitic languages, namely Arabic. In a number of diverse languages in which uvulars lower or back vowels (such as Aymara, Jaqaru, Kashaya, Ubykh), all uvulars affect vowels identically. A possible explanation for the differential patterning of /q/ and uvular fricatives is offered by Moisik (2013:463-467), which describes how uvular stops, such as /q/, may have only very weak tongue retraction ({**tre**}) whereas tongue retraction may be a much more prominent gesture for uvular fricatives (/χ, ʁ/). Rather than associating tongue retraction with all uvulars by making it definitional of a feature (such as [+raised]), tongue retraction can be associated only with uvular fricatives by being associated with their primary allophones in Arabic, not with their universal phonological feature representation. This allows the differential patterning of /q/ and /χ, ʁ/ in Arabic to be explained phonetically and for that explanation to be used in formal phonological derivations, but avoids the undesirable prediction that /q/ and /χ, ʁ/ will behave differently in every language.

## 4.5 Summary and Conclusions

This chapter has given a history of research into phonological features (§4.2) and has defended the continuing relevance of research into phonological representations (§4.2.3). This chapter has also reviewed specific proposals of previous researchers on the representation of post-velar consonants (§4.3). Reviewing these proposals highlighted fundamental weaknesses in the featural representations proposed in the *Sound Pattern of English* (§4.3.1.2) and within the framework of Feature Geometry (§4.3.2).

This chapter proposed a new understanding of the phonological representation of segments whereby phonetic subfeatures are associated with both phonological features and with the language-specific allophones of phonemes (§4.4, summarized in Figure 4.9). A new phonological featural representation for the post-velar consonants that was motivated entirely by cross-linguistically attested contrasts was proposed in §4.4.2. The phonetic subfeatures needed to characterize post-velar consonants and their relationship to phonological features was discussed in §4.4.3.

The conception of phonological representation proposed in this chapter distributes the functions that phonological features have come to fulfill to different elements of representation. Phonological features are responsible only for capturing phonemic contrast and phonetic subfeatures are used to incorporate language-specific phonetic detail. Both of these kinds of representations can also be used, as is the case in every approach, to identify sets of segments. The approach proposed here notably does not advocate the use of phonological representations to explain phonological natural class generalizations, contra most proposals on phonological representation since Chomsky

[38] Other examples include the realization of pharyngealized vowels in Lak and the effects of uvular allophones of /x/ and /n/ in Filomeno Mata Totonac, both mentioned in §4.4.

and Halle (1968). It will be shown in later chapters that previous representational approaches to capturing natural class behavior have weaknesses that cannot be surmounted by continuing to try to refine the representations of segments. Instead, natural classes are proposed to be derived directly from phonetic similarity among segments.

# Chapter 5

# Phonological Classes

## 5.1 Introduction

Since at least Chomsky and Halle (1968), the distinction between natural and unnatural phonological classes has been identified as a fact that phonological theory must explain. Chomsky and Halle (1968) write that "... it is the 'natural' classes that are relevant to the formulation of phonological processes in the most varied languages, though there is no logical necessity for this to be the case." A form of this generalization also prompted the development of Feature Geometry (Sagey 1990:1). Certain groupings of features were seen to pattern together more frequently than others. Moreover, these groupings could often be unified by a phonetic (especially articulatory) characteristic. Such classes were deemed to be "natural" because of both their cross-linguistic frequency and their clear phonetic bases.

However, not all phonological classes are natural. The Ruki Rule in Sanskrit changes /s/ to /ʂ/ after the phonemes /r, u, k, i/, which form a phonological class by virtue of the fact that they function as triggers for a single phonological process. The members of the group /r, u, k, i/ share no obvious phonetic characteristic that can explain their patterning, nor is their patterning observed in other languages. Because there is no phonetic characteristic that unifies the members of the class and the class is not cross-linguistically common, the class is not considered natural. Another example of an unnatural class is /v, s, g/ in Evenki, which, to the exclusion of other consonants, become nasal when they follow nasal consonants and occur in stem-final position (Mielke 2008:120 citing Nedjalkov 1997:175, 320).[1]

An important goal of phonological theory is to formally capture the difference between natural and unnatural classes. An overarching guiding principle has been that "... the relative simplicity of describing in the [formal] representation each process or form that occurs should reflect its relative naturalness, in the sense of its frequency of occurrence in the languages of the world" (Sagey 1990:1). In attempting to simplify the representation of cross-linguistically frequent phonological classes, earlier theoretical frameworks, especially Feature Geometry, severely restrict the formal expression of these classes. This formal expression was restricted to such an extent in Feature

[1] For additional details including data, see §5.3.5.

Geometry that the theory sometimes fails to account for classes that have straightforward phonetic explanations, which would be considered natural by most phonologists. Allowing frameworks to define phonological classes more flexibly increases their empirical coverage, but at the cost of predictive and explanatory power.

The goal of this chapter is to propose a new method for deriving natural classes in phonological theory. First, in §5.2, a typology of phonological classes (based on Mielke 2008) is explained to establish working terminology that is necessary for discussing previous conceptions of phonological classes in §5.3. Reviewing these previous accounts highlights the benefits and drawbacks of each approach, setting the stage for a new proposal for how to differentiate types of phonological classes and derive natural classes (§5.4). The proposal, broadly, is to derive phonological natural classes using a family of constraints, ASSOC($\complement_i$, $p \leftrightarrow q$), that uses the co-occurrence of phonological features and phonetic subfeatures in cross-linguistically attested phonemes to establish links that license the grouping of sets of phonemes into feature classes ($\complement_i$). This proposal is explained in detail throughout §5.4. The chapter concludes by laying out the predictions that arise from this framework.

## 5.2 Working Definitions of Types of Phonological Classes

Groups of phonemes form a phonological class in a language if they "undergo a phonological process, trigger a phonological process, or exemplify a static distributional relation" (Mielke 2008:13). Mielke (2008:12-13) describes the types of logically possible phonological classes more generally in terms of two parameters: 1) Naturalness, and 2) being phonologically active or inactive. A phonological class is considered "natural" to the extent that its membership can be explained straightforwardly from phonetic properties. The definition of naturalness could be extended to include other sources, such as social pressures, possible cognitive biases, and other factors, some of which may affect only synchronic or only diachronic phonology. In this study, a group of sounds is phonologically active if they form a phonological class in the language on the basis of evidence from a synchronic process or distributional constraint.

With respect to these two parameters, four types of phonological classes can be defined: 1) Phonologically active natural classes, 2) phonologically active unnatural classes, 3) phonologically inactive natural classes, and 4) phonologically inactive unnatural classes. Characterizing phonological classes in these terms allows them to be identified outside the context of specific theories. The types of phonological classes are defined explicitly below with examples.

(79) Phonologically Active Natural Class

a. *Definition*:
A phonologically active natural class is a group of sounds in a language that:
1. must be referred to by that language's synchronic phonology to characterize a phonological process or distributional constraint, and
2. whose grouping can be explained in terms of phonetic factors that exclude all other sounds.

b. *Example*:
Nasal consonants in Imbabura Quichua, which assimilate in place to a following consonant and voice that consonant if it is /p, t, k/ or /t͡ʃ/ (Field research; confirmed in Cole 1982:199-201).

(80) Phonologically Active Unnatural Class

a. *Definition*:
A phonologically active unnatural class is a group of sounds in a language that:
1. must be referred to by that language's synchronic phonology to characterize a phonological process or distributional constraint, and
2. whose grouping cannot be explained in terms of phonetic factors that would exclude all other sounds.

b. *Example*:
The phonemes /v, s, g/, which nasalize in stem-final position following nasal consonants in Evenki (see §5.3.5).

(81) Phonologically Inactive Natural Class

a. *Definition*:
A phonologically inactive natural class is a group of sounds in a language that:
1. does not need to be referred to by that language's synchronic phonology to characterize any phonological processes or distributional constraints, and
2. whose grouping could be explained in terms of phonetic factors that would exclude all other sounds.

b. *Example*:
Retroflex consonants in American English: Retroflex consonants are cross-linguistically well-attested and have a straightforward articulatory explanation, but are not referred to by the phonology of American English. Phonologically inactive natural classes can also include segments that are part of the phonemic inventory and have a clear unifying phonetic characteristic, but are not used as a natural class in the language's phonology.

(82) Phonologically Inactive Unnatural Class

a. *Definition*:
A phonologically inactive unnatural class is a group of sounds in a language that:
1. does not need to be referred to by that language's synchronic phonology to characterize a phonological process or distributional constraint, and
2. whose grouping could not be explained in terms of phonetic factors that would exclude all other sounds

b. *Example*:
The sounds /ɟ, ɢ, ʘ/ for English: These consonants are cross-linguistically attested, but they are not referred to by English phonology, and their grouping could not be explained by any phonetic characteristics that would exclude all other sounds.

Theories of phonology attempt to identify and predict phonologically active and inactive natural classes. However, they also must be able to model or describe phonologically active unnatural classes. Finally, it should be noted that the last logically possible type of class in (82) is arguably not truly a class since there is no basis in observed evidence for its existence. For this reason, it will not be dealt with further.

With relatively theory-neutral terminology established, it is now possible to compare different theoretical conceptions of phonological classes in a precise way that clarifies the benefits and drawbacks of each approach.

## 5.3 Previous Theoretical Conceptions of Phonological Classes

### 5.3.1 Feature Sets

Natural classes (either active or inactive) were first explicitly defined within a theoretical framework by Chomsky and Halle (1968:335), who wrote that "sets of segments that have features in common are more natural than sets of segments that have no common features." They cautioned, however, that "it is actually the content of the features and not the form of the definition that decides these questions of naturalness" (401). In fact, they cite numerous examples of the inadequacy of defining naturalness purely in terms of features. One example is that "the class of voiced obstruents is, intuitively, more natural than the class of voiced segments (consonant or vowel), but the latter has the simpler definition" (400). Another example (which is especially relevant to claims made in Padgett (1995)) is that "[t]he class of vowels which are the same in backness and rounding (i.e. the class [αback, αround]) is more natural than the class of vowels which have the same coefficient for the features 'low' and 'round' (i.e. the class [αlow, αround], which contains [i e ɨ ʌ æ ɔ]); in spite of this the same number of features enters into each characterization" (Chomsky and Halle 1968:400).

The important contribution of Chomsky and Halle (1968) was not their specific formulation of a naturalness metric, whose insufficiencies they openly acknowledged, but their declaration that a formal naturalness metric was an obligatory element of a sufficiently explanatory theory of phonology (335).

### 5.3.2 Feature Geometry

The development of Feature Geometry can be seen as a renewal of interest in formalizing claims about the naturalness of phonological classes. Despite the fact that Chomsky and Halle (1968:400-401) acknowledged that their formal naturalness metric "in many cases … fails completely" and that examples of classes with identical numbers of features but differing naturalness "are quite easy to find," no other formal metric of naturalness gained widespread acceptance until the advent of Feature Geometry. Feature Geometry formalizes the concept of naturalness by organizing phonological features into natural classes which are unified by articulatory phonetic facts.[2] These natural

[2]For details on the phonetic rationale for aspects of Feature Geometry, see §4.3.2.

classes of features are formally instantiated as nodes which dominate the features that belong to the natural class, as seen previously in (4.3). For example, in Sagey (1990:205), the Dorsal node dominates the features [±high], [±low], and [±back].

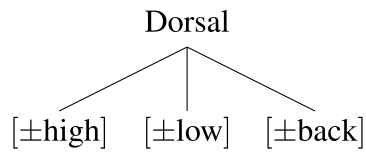


Figure 5.1: The Dorsal node in the feature geometry of Sagey (1990:205)

In Feature Geometry, natural classes are groups of features that are all dominated by a single node. If one views nodes as sets of features, e.g. Dorsal = {[±high], [±low], [±back]}, then a natural class in Feature Geometry is the exact set corresponding to a node. Neither a subset, such as {[±high], [±back]} nor a superset, such as {[±high], [±low], [±back], [±round]}, is a natural class unless that subset or superset corresponds to a specific node in the geometry.

Feature Geometry performs best on phonological classes whose naturalness is based on distinctions that relate to place of articulation. One reason for this may be that the terminal features (such as [distributed]) that are dominated by Place nodes (like Coronal) distinguish smaller phonetic differences than do the major manner features, such as [nasal], [continuant], and [sonorant]. Conceivably, these features could be elevated to a status on par with Place nodes and defined as dominating lower-level phonetic features. For example, [continuant] could be elevated to Continuant and made to dominate features that define a subset of its segments, such as [strident]. That is, implicational relationships in which the existence of one terminal feature implies the existence of another higher node for phonetic reasons could be used to elaborate Feature Geometry. The lack of elaboration among manner features therefore reflects a stipulated bias toward favoring fine-grained place-of-articulation-based explanations rather than an intrinsic requirement that feature geometries be based only on articulator-based distinctions.

The naturalness metric proposed by Chomsky and Halle (1968) and the one proposed as part of Feature Geometry are fundamentally different. The naturalness metric in Chomsky and Halle (1968) is somewhat gradient in the sense that it is possible to say that a class is more or less natural than another. Feature Geometry does not allow for differing degrees of naturalness: A phonological class is either one of those defined as natural by the theory or it is not. Even if a phonological class differs as minimally as possible from the class defined in the theory to which it is most similar, it is non-natural according to the theory.

Although Feature Geometry generates precise predictions about which phonological classes are natural, it is arguably descriptively inadequate. As has been noted, phonetics is standardly adopted as a reasonable empirical basis for naturalness in phonology. From this premise, any phonological class with a straightforward acoustic explanation will be judged as natural by most phonologists. However, some of these will have to be classified as unnatural in Feature Geometry because they may not correspond to the classes defined as natural based on predetermined features and hierarchical organizations of those features.

For example, Hyman (1973) shows that the Jakobsonian feature [±grave], an acoustic feature characterized by a "concentration of energy in the lower frequencies of the spectrum" (Hyman 1973:329 citing Jakobson and Halle 1956), accurately captures the phonological class generalization attested in high vowel reduplication in the Fe'fe' dialect of Bamileke (Grassfields Bantu). In this process, a $C_1$V(V) syllable is reduplicated by default as /$C_1$ɯ/ to produce words with the shape /$C_1$ɯ$C_1$V(V)/ (Hyman 1973:333-334).

(83) Default pattern of high vowel reduplication in Fe'fe' (Hyman 1973:333)[3]
za 'to eat' → zɯza
to 'to punch' → tɯto

When the stem vowel is /i/, the reduplicated vowel surfaces as /i/.

(84) High vowel reduplication when stem vowel is /i/ (Hyman 1973:333)
pii 'to profit' → pipii
sii 'to spoil' → sisii

But when the stem vowel is /e, ɛ/ or /a/, the reduplicated vowel surfaces with a value of the feature [±grave] that is identical to that of the stem's onset consonant. Thus, when the consonant is [-grave], the vowel is /i/, which is also [-grave]. Otherwise, if the consonant is [+grave], the vowel surfaces as /ɯ/, which is [+grave]. The alveolar and palatal/postalveolar places are [-grave] while the labial and velar places are [+grave] (Hyman 1972:17, 1973:333).

(85) High vowel reduplication when stem vowel is /e/ (Hyman 1973:333; place of articulation for the onset consonant is noted)
pėe 'to hate' → pɯpėe (Labial)
tee 'to remove' → titee (Alveolar)
jee 'to see' → jijee (Palatal)
kėe 'to refuse' → kɯkėe (Velar)

(86) High vowel reduplication when stem vowel is /ɛ/ (Hyman 1973:334)
pɛn 'to accept' → pɯpɛn
tɛn 'to stand up' → titɛn
t͡ʃɛn 'to moan' → t͡ʃit͡ʃɛn
ɣɛ̇n 'to go' → ɣɯɣɛ̇n

(87) High vowel reduplication when stem vowel is /a/ (Hyman 1973:334)
paʔ 'to commit suicide' → pɯpaʔ
taʔ 'to bargain' → titaʔ
t͡ʃaʔ 'to trample' → t͡ʃit͡ʃaʔ
kaʔ 'to grill' → kɯkaʔ

These data show that the class of grave consonants is a synchronically active phonological class united by an acoustic phonetic characteristic (Hyman 1973). Although many phonologists would

[3] Hyman (1973:333) notes that "[t]he reduplicated forms have a number of uses in Fe'fe', though I shall not be concerned with these here." Thus, glosses are not provided. Tone is also unmarked here and in the source.

consider this a natural class on the basis of its simple phonetic characterization, it must be termed an unnatural class in Feature Geometry. The [+grave] consonants, which would fall under the Labial and Dorsal nodes, could not be formally grouped to the exclusion of the Coronal node. Moreover, the [-grave] consonants also do not exactly match the Coronal node since the palatal/ post-alveolar consonants, by virtue of being considered non-anterior by Chomsky and Halle (1968:304), would not be classified as Coronal.

Even if Feature Geometry were reorganized to reflect the grouping of Labial and Dorsal (perhaps through a node called Grave positioned below the Place node, but dominating Labial and Dorsal), additional data from other languages would motivate another incompatible grouping of the major Place nodes. For example, data from Chechen (Nakh-Daghestanian) motivates a grouping of places of articulation in which all the places of articulation farther forward than the Dorsal place are grouped together to the exclusion of Dorsal. In Chechen, Dorsal consonants cannot be pharyngealized, but consonants at all more anterior places of articulation can be (Nichols and Vagapov 2004:21). This example proves that further subgrouping within the Place node that universally reflects the cross-linguistic groupings of the major places is impossible.

In Feature Geometry, nodes and individual features are the representational entities to which phonological rules and constraints can refer. The prediction of Feature Geometry is that rules and constraints will reference single individual features and nodes, but not, for example, only two of the three features under a given node (like Dorsal). One would also not expect a process that, for example, spreads only some of the features of multiple nodes, e.g. spreading the features [±distributed] and [±high] together to the exclusion of the other features in the Coronal and Dorsal nodes, respectively. Cases in which only a few features of a node (not all) or features that are members of different nodes pattern together in rules or constraints are termed partial class behavior by Padgett (2002:83). As an example, Padgett (2002:84) cites harmony with respect to vowel color (roundness and backness) in Turkish as an example. In the feature geometry of Sagey (1990), [±round] is under the Labial node and [±back] is under the Dorsal node. Thus, harmony with respect to vowel color involves a feature under the Dorsal node and a feature from under the Labial node. This kind of partial class behavior is not expected under Feature Geometry, which highlights an architectural problem with the framework. By exhaustively specifying the list of possible natural classes, Feature Geometry is too inflexible to admit the possibility of any other phonological classes, even if they are robustly attested and are phonetically natural.

Another problem for Feature Geometry is when a feature displays behavior that motivates linking it to more than one node. Phonological processes that refer to vowel color motivate linking [round] not only to the Labial node, but to the Dorsal node. The existence of labiovelar /w/ and /ʍ/ further motivate such a linkage. Another possible example comes from the feature [±low] in its original form from Chomsky and Halle (1968), whose positive value was used for both vowels and consonants. This use was justified partially through the observation that "the superimposed subsidiary articulation is … [a]-like" in pharyngealization (306). This dual usage of [±low] for vowel quality and (specifically [+low]) for pharyngealization is what could cause problems in a Feature Geometric representation.[4] If a positive value for the feature [±low] were used to represent

[4]The proposal to split the representation of primary and secondary articulations into C-place and V-place by Ní

pharyngealization in Sagey's feature geometry, it would be linked to the Tongue Root node since the tongue root has been shown to be involved in pharyngealization. However, it would still be necessary to link it to the Dorsal node because of its role in vowel harmony, as in Fanti Akan /r/ assimilation (described in §4.3.2.1). Finally, if [±low] were still used to characterize the glottal consonants as in SPE, [±low] could potentially be linked to the Laryngeal node as well (under the view that the larynx is an active place of articulation, which is non-standard in work on Feature Geometry). Apart from the strong phonetic evidence that [+low] is not the proper characterization for pharyngeals, glottals, or even low vowels (Esling 2005:23), the problem of [±low] potentially associating with two (or even three) nodes necessitates a different formal conception either of the articulation of /a/, of the articulation of the glottals, or of the articulation of pharyngeals and pharyngealized consonants in Feature Geometric terms.

A related problem for Feature Geometry is ambivalent segments such as uvulars and glottals. These segments are called ambivalent in this study because the patterning of these phonemes with other places of articulation can differ both across and within languages.[5] In some languages (e.g. Arabic), the glottals pattern with the pharyngeals, but in others (e.g. Interior Salish languages) they appear not to (Bessell 1992; but cf. Rose 1996). Similarly, in some languages, uvulars pattern with velars (as dorsals) while in others they pattern with pharyngeals (as gutturals, faucals, etc.). For example, in the Northeastern Turkic languages Shor, Tuva, and Dolgan, uvulars and velars are in complementary distribution with uvulars appearing in words with back vowels and velars appearing in words with front vowels.[6] In these languages, the uvulars and velars are distinct allophones and not phonemically distinct. Although uvulars pattern with pharyngeals in most cases in Arabic, the uvulars also display strong co-occurrence restrictions with velars in roots, which provides evidence that the velars and uvulars pattern together. More specifically, /q/ never co-occurs in roots with /k, g/ and /χ, ʁ/ co-occur with them only in a single root (McCarthy 1994:204). However, the uvulars in Arabic, especially fricatives, pattern with the pharyngeals in root co-occurrence constraints as well as multiple processes that lower adjacent vowels. Accounting for the behavior of ambivalent segments is a problem because it motivates differing representations for those segments in which possibly non-contiguous nodes must be grouped together or in which features that are not under the same node must be grouped together. Feature Geometry is fundamentally ill-equipped to handle this type of variation.

A solution to many of the problems that arise for Feature Geometry based on cross-linguistic variation is the contrastive hierarchy approach advocated by Dresher (2009). Contrastive hierarchies start from a universal set of features (16), and divide the phonemes of a language based on one of those features, then divide those subsets in the same way successively until every set has only one member (ibid.). This process is called the Successive Division Algorithm (SDA; ibid.). Crucial to this approach is the order in which features are used to subdivide the inventory (17-30), since segments characterized early in the course of the SDA will not be specified for features characterized later. Manipulating the order of these features is how language-specificity can be

Chiosáin and Padgett (1993) would allow consonants to carry V-place features, and this would let a feature like [+low] spread from a pharyngeal consonant without necessarily being used to define its primary articulation.

[5] Yamane-Tanaka (2006) also uses the term 'ambivalent' to designate this situation.

[6] See §2.2.8 and §2.2.7 for descriptive references for these languages.

captured. While this approach can solve problems presented by cross-linguistic variation, variation internal to a language, such as that posed by ambivalent segments (e.g. uvular fricatives in Arabic), remain a potential problem.

Finally, Feature Geometry cannot model phonologically active unnatural classes, except through the traditional mechanisms offered by a rule based account, such as feature disjunction and the use of multiple rules (Flemming 2005). Evenki (Tungusic) provides an example of a phonologically active unnatural class (/v, s, g/) that is predicted to be impossible by Feature Geometry. In Evenki, the phonemes /v, s, g/ nasalize to become /m, n, ŋ/, respectively, after a nasal consonant (Mielke 2008:120 citing Nedjalkov 1997:175, 320).

(88) Evenki /v, s, g/ nasalize after nasals (Nedjalkov 1997)[7]

| | | | |
|---|---|---|---|
| /oron-vi/ | → | oron-mi | 'my reindeer (sg.)' (149) |
| /ŋinakin-si/ | → | ŋinakin-ni | 'your dog' (320) |
| /oron-gAt͡ʃin/ | → | oron-ŋot͡ʃin | 'like a/the reindeer' (149) |

(89) Other consonants do not nasalize after nasals in Evenki (Nedjalkov 1997)

| | | | |
|---|---|---|---|
| /amkin-du/ | → | amkin-du | 'bed (DAT)' (175) |
| /ekun-da/ | → | ekun-da | 'somebody/something/anything' (164) |
| /oron-dɯn/ | → | oron-dɯn | 'like a reindeer in size' (149) |

Although a representational solution is unavailable since the phonemes /v, s/ and /g/ are not a phonetically natural grouping, their combined action can be modeled using multiple rules, as in (90). This shows that representational restrictions on natural classes do not rule out the possibility of /v, s/ and /g/ acting as a phonologically active class.

(90) Multiple rules can derive /v, s, g/ as a phonologically active class

v → [NAS, -cont, +voi] / [NAS]__
s → [NAS, -cont, +voi] / [NAS]__
g → [NAS, -cont, +voi] / [NAS]__
*or* {v, s, g} → [NAS, -cont, +voi] / [NAS]__

Because these rules generate the same output (nasal consonants) in the same environment (after nasals), their target segments, /v, s, g/, act together as a phonologically active class. This highlights another core architectural problem with Feature Geometry: Its restrictive power can be circumvented through the action of multiple rules (Flemming 2005).

In summary, Feature Geometry makes clear predictions, but these predictions are shown to be wrong in certain languages. However, proposing a different configuration of features will not solve the core architectural problem with Feature Geometry, which is the rigidity of its hierarchical feature organization. This rigidity lends the framework its predictive power, but prevents it from capturing cross-linguistic and language-internal variation.

[7] Mielke (2008:120) notes that "/A/ is an archiphoneme whose phonetic realization is determined by the preceding harmonic vowel." For more details on vowel harmony in Evenki, see Nedjalkov (1997:314-315).

### 5.3.3 Feature Class Theory

Padgett (1995; 2002) proposes an alternative to Feature Geometry called Feature Class Theory that has increased flexibility and preserves the core insights of Feature Geometry on phonological patterning. In Feature Class Theory, phonological classes are "understood as set-theoretic postulates" (Padgett 2002:82) that group individual features into representational entities called *feature classes*. For example, the feature class Place may be the set {[labial] ∪ [coronal] ∪ [dorsal] ∪ [pharyngeal]} (82, 96). Feature Class Theory allows more phonological classes to be referred to than does Feature Geometry, and it also allows subsets of phonological classes to be referred to. Using examples of partial class behavior as evidence, Padgett (2002) argues that features are always targeted individually, since in the same language (e.g. Turkish) both a whole class (e.g. Color, which includes [back] and [round]) and a portion of the class (e.g. [back]) may need to be referred to by separate harmony processes (88). Feature Class Theory improves on Feature Geometry by allowing subsets of phonological classes (composed of multiple features) to be referred to, since only terminal features are ever actually targeted, and by allowing new phonologically-motivated groupings of features to be defined. This eliminates the inflexibility inherent in Feature Geometry by rendering the groupings of features in that theory as sets which may be referred to, but need not be.

One of the main problems with Feature Class Theory as it is stated in Padgett (2002) is that feature classes are postulated, not derived (82). This means that feature classes are formally stipulated (albeit on the basis of reliable phonological and phonetic evidence), which causes two problems. First, the framework does not formally incorporate a source of explanation, which allows it to model data, but not necessarily to explain it. Second, the lack of a derivational method for arriving at feature classes means that it cannot be formally restricted. The set of feature classes that can be postulated is proposed to be limited by "the assumption that the classes have a phonetic basis" (96), but there is no way to formally prevent the composition of feature classes that produce phonetically unnatural classes. Later in this study, in §5.4, a theoretical framework for deriving feature classes is proposed, and feature classes themselves are discussed in more detail in §5.4.2.2.

### 5.3.4 Emergent Feature Theory

In the approaches that have been reviewed thus far, minimal phonemic contrasts have motivated universal features that are defined according to the phonetic dimension on which the contrast is based, e.g. voicing. These features, like the familiar [±voiced], are used both to describe segments and to formalize phonological processes and distributional constraints. They are also used as the primitive representations that serve to define natural classes, which are in turn based on evidence from cross-linguistically common groupings of phonemes.

In Emergent Feature Theory (EFT), surface phonological processes and distributional constraints form the basis for features, rather than being formulated in terms of them (Mielke 2008:81). While a feature in traditional conceptions is a phonetic dimension along which phonemic contrast is possible, a feature in EFT is a label for a phonological class. The predictions of the traditional conception can be directly compared with EFT by comparing how these two approaches define sets of phonemes. In the traditional conception (in SPE, here), only a defined number of sets (including their intersections) from among all the possible sets of segments are predicted to be used in phonological processes and distributional constraints since these are the sets that can be formulated based on traditional phonological features. However, in EFT, all the possible sets of phonemes are predicted to be allowed to occur.

As this latter prediction shows, in EFT, no phonological classes are ruled out, and there is no categorical distinction between natural and unnatural classes. Instead, formally speaking, classes are considered more or less natural based on their frequency of occurrence in the world's languages. Phonological classes are predicted to be more frequent based on how they fare with respect to the factors that can influence diachronic sound change, such as articulation, perception, social identity, etc., which act as selective pressures (Mielke 2008:82). Where to place the boundary between natural and unnatural is formally a matter of choice on the part of the researcher, since no part of the system explicitly defines a boundary.

### 5.3.5 Flemming 2005: Deriving Natural Classes via Constraint Interaction

Flemming (2005) presents a proposal for how phonological classes should be understood in the context of Optimality Theory (OT; Prince and Smolensky 1993), and advocates the idea that constraints and their interaction, rather than representations, drive the formation of natural classes. Representational solutions, such as Feature Geometry, directly specify which phonological classes are natural. This heavily restricts the groupings of phonemes that can play a role in phonological processes and statements of distributional restrictions, which leads to highly specific predictions (even though this comes at the cost of inadequate empirical coverage). However, Flemming (2005:289-290) notes that the explanatory power imparted by the restrictiveness of representational natural classes is annulled by the ability to use multiple rules. If the set of sounds that trigger or undergo a process cannot be specified with reference to a single feature bundle, then multiple rules that are otherwise the same, but refer to each sound in the set individually, can be used to achieve the same effect that would be achieved if the sounds were made to be a representational natural class. Flemming (2005) proposes using this very derivational power to derive natural classes instead of attempting to specify the possible natural classes using a representational solution.

Flemming (2005) proposes deriving phonologically active classes through the interaction of multiple constraints since this power is already available in phonological theory and obviates any representational restrictions that could be imposed. Because Flemming (2005) works within the context of Optimality Theory, phonologically active classes are not derived from the interaction of multiple rules, but from the interaction of multiple constraints. Flemming (2005) argues that sets of sounds that act together as undergoers (291-292) or triggers (292-294) in phonological processes form phonologically active classes because they are treated alike by the constraint set in the given derivation in which they act together. The definition of a "natural class" in Flemming's terms, then, is a grouping of sounds which are treated alike with respect to some constraint set.

This means that Flemming (2005) uses the term "natural class" to refer, in the terminology adopted here, to any phonologically active class, natural or unnatural. This is because Flemming's formal conception of "naturalness" is not defined with respect to phonetics (or history, etc.), but with respect to phonology. Thus, if a class of sounds is phonologically active, this is evidence that it is phonologically "natural." It is important to note that Flemming (2005) does, of course, recognize the role of phonetic factors, but these are understood to be implemented via phonology. Phonology itself is in turn modeled using Optimality Theory, and it is the content of the constraint set, i.e. CON, that determines which classes are phonologically natural. On the relationship of phonetics to phonology with respect to deriving natural classes, Flemming (2005:300) writes that "sounds that are marked in the same environment often share phonetic properties because many markedness constraints have a phonetic basis, so the constraint-based analysis is consistent with the generalization that natural classes involve phonetically similar sounds, but it is the shared environment of markedness that is essential, not the shared phonetic properties."

Flemming's approach allows any phonologically active class to be derived, not just natural classes. Therefore, it is able to derive phonologically active unnatural classes, such as that in Evenki (Tungusic) described in §5.3.2. Recall that in Evenki, /v, s, g/, to the exclusion of all other phonemes, nasalize after stem-final nasal consonants. A simplistic analysis that illustrates how the combined action of several constraints can derive a phonological class is given in (91), which derives the word *oronmi* 'my reindeer (sg)' from the underlying form /oron-vi/. Markedness constraints of the form *[NAS]X (abbreviated *NX), where X is any phoneme, are used to prevent the occurrence of sequences like /nv/. To promote the repair of these segments, the constraint MAX([NAS]) is ranked above these constraints to prevent nasality from being eliminated to make the repair, and the faithfulness constraints IDENT-IO([cont]) and IDENT-IO([voi]) are ranked below the markedness constraints. This allows /v, s, g/ to change to /m, n, ŋ/, respectively.

(91) Deriving the phonological classhood of /v, s, g/ in Evenki

| | /oronvi/ | MAX([NAS]) | *Nv | *Ns | *Ng | ID-IO([cont]) | ID-IO([voi]) |
|---|---|---|---|---|---|---|---|
| → | oronmi | | | | | 1 | |
| | orovvi | 1! | | | | 1 | |
| | oronvi | | 1! | | | | |
| | oronsi | | | 1! | | | 1 |
| | orongi | | | | 1! | 1 | |

In this tableau, /v, s, g/ are treated alike with respect to the markedness constraints of the form *[NAS]X, and can therefore be considered a phonologically active class.

The problem with Flemming's approach is that it does not derivationally distinguish, in the terminology of this study, natural classes from unnatural classes. This distinction is an important source of predictions about which classes should be cross-linguistically common, and without making this distinction, the theory predicts that all phonologically classes should be equally likely to occur in a language. Flemming's framework shares this inadequacy with Mielke's Emergent Feature Theory approach.

Despite this problem, a core insight in Flemming (2005:307) is retained in this study, namely the idea that "[s]ounds can pattern together [as a phonologically active class; JCS] if they are marked in the same environment according to one or more constraints" or if "a higher-ranked constraint can prevent a subset of a class from undergoing a process" (307). As will be discussed in §5.4, this idea is used here to derive phonologically active unnatural classes.

## 5.4 Deriving Phonological Classes

In this section, I present a new proposal on how phonologically active classes are derived. The broad outline of this proposal is that phonologically active unnatural classes are derived as the epiphenomena of constraint interaction as proposed by Flemming (2005). Phonologically active natural classes, however, are derived as feature classes (Padgett 1995, 2002), symbolized as $\mathbb{C}$. Feature classes are sets of feature bundles (bundles of phonological features or phonetic subfeatures) that are joined in union relationships. Membership in these classes is determined primarily by a new type of Optimality Theory constraint (ASSOC($\mathbb{C}_i$, $p \leftrightarrow q$)), explained in §5.4.2.3. These constraints call for two feature bundles, $p$ and $q$, to be present in a feature class. These two feature bundles are linked by phonological entailments (explained in §5.4.2.1), which link feature bundles if they co-occur within the representation of a single phoneme attested in a language of the world. The discussion that follows develops a theoretical framework based on the idea of using entailments to derive natural classes, and uses hypothetical examples for illustration throughout. In chapter 6, this framework is used to derive attested phonological classes that were found in the survey of phonological patterns that involve post-velar consonants (chapter 3).

### 5.4.1 Phonologically Active Unnatural Classes

The phonologically active unnatural classes are derived along the lines proposed in Flemming (2005). Membership in a phonologically active unnatural class includes phonemes that are treated identically by constraints (i.e. share the same violation profile) that model the phonological process or distributional constraint that provides evidence for the class being phonologically active. Thus, the phonologically active unnatural classes are derived as a byproduct of constraint interaction. No unifying factor is proposed for the phonemes in these phonological classes beyond the fact that they are treated identically with respect to certain processes or distributions. This method of deriving phonologically active unnatural classes as epiphenomenal is ideal since no other factor than their phonological behavior necessarily explains the unification of the phonemes as a class.

No previous study quantitatively assesses the prevalence of phonologically active classes that are truly "unnatural," i.e. no phonetic explanation can characterize them to the exclusion of other phonemes. Mielke (2008:118) writes that none of three common feature systems (including that of *Preliminaries to Speech Analysis* Jakobson et al. (1952), SPE (Chomsky and Halle 1968), and Unified Feature Theory (Clements and Hume 1995)) can account for 1,498 (24.65%) of the 6,077 phonologically active classes in his cross-linguistic survey. Some of these classes (exemplified with data from Kolami, Evenki, River West Tarangan, and Thompson; Mielke 2008:118-124) are truly unnatural and cannot be accounted for by any unifying phonetic properties. Mielke (2008:123-124) implies that these are a small minority of cases, and that other phonologically active classes are likely to be phonetically natural.

### 5.4.2 Phonologically Active Natural Classes

Since Chomsky and Halle (1968), phonological theory has captured phonologically active natural classes either through representation (SPE, Feature Geometry, Feature Class Theory) or derivation (Flemming 2005). Representational solutions capture important empirical generalizations, but are generally too inflexible to make use of the phonetic explanations that linguists are able to discover to explain phonological classhood. One reason for their inflexibility is that phonological theory has generally relied on a single, cross-linguistically invariable feature representation for all phonemes and has expected that representation to accurately model phonological contrast, capture phonetic details that are phonologically relevant but non-contrastive, and derive generalizations about phonological classhood. I proposed in chapter 4 that representations should be responsible only for these first two tasks, and moreover that a separate aspect of phonemic representation should be used for each of these tasks.

Recognizing the inflexibility of representational solutions and the need for integrating generalizations about phonological classhood from Feature Geometry into Optimality Theory, Padgett (1995, 2002) proposed Feature Class Theory. This contributed a flexible framework for modeling natural classes and distinguishing them from unnatural classes, but did so stipulatively (albeit on the basis of cross-linguistic data and phonetic generalizations). Feature Class Theory, then, integrated representational solutions for capturing phonological classhood generalizations into a derivational framework, Optimality Theory, but did not actually derive natural classes.

Flemming (2005) represents the first fully derivational approach to expressing generalizations about phonological classhood. However, his system derives all phonologically active classes in the same way, as byproducts of constraint interaction. The derivational mechanism itself does not formally distinguish between what are termed here natural and unnatural classes. Instead, phonetics influences the frequency of phonological classes indirectly through the constraints that define which segments are affected in a derivation.

The approach that I propose here is a method for deriving phonologically active natural classes in Optimality Theory. This method augments Feature Class Theory because it derives feature classes, thus removing the need to stipulate them. Deriving phonologically active natural classes this way formally differentiates them from unnatural classes, which are derived through constraint interaction as suggested by Flemming (2005). The details of how feature classes are derived are the subject of the following sections. Because phonological entailments are a fundamental concept used for motivating the regulation of membership in feature classes via the ASSOCIATE constraints, they are discussed in §5.4.2.1 before feature classes and the ASSOCIATE constraints, which are presented in §5.4.2.2 and §5.4.2.3, respectively.

#### 5.4.2.1 Entailments

In formal logic, entailments are assertions that if a certain precondition, $p$, exists, then the existence of another condition, $q$ (the dependent consequent), is guaranteed. Entailments are abbreviated as $p \rightarrow q$. The concept of an entailment originated in formal logic and has been applied in other domains, such as (truth conditional) semantics, for which Levinson (1983:174) gives the definition in (92).

(92) Levinson's (1983:174) definition of semantic entailment:
A *semantically entails* B (written A ‖- B) iff every situation that makes A true, makes B true (or: in all worlds in which A is true, B is true)

Entailments are a general means of expressing that the existence of one entity (*p*) ensures the existence of another (*q*).

Entailments have also been adapted for use in phonology and morphology by Burzio (2002a,b), who grounds the concept of an entailment in principles from connectionist, Hebbian learning. This is done through positing the idea of *representational entailments*, defined in (93).

(93) Representational Entailment Hypothesis of Burzio (2002a:176):
Mental representations of linguistic expressions constitute sets of entailments - a representation with the structure AB generating the entailments A $\rightarrow$ B, B $\rightarrow$ A.

In phonological terms, this can be understood as saying that mental representations of phonemes constitute sets of symmetrical entailments, such that the valued features of a phoneme all mutually entail each other. The idea that co-occurring elements entail each other is the intersection point with principles of connectionist, Hebbian learning. Hebb (1949:62) (quoted in Burzio 2002a:176) wrote that "[w]hen an axon of a cell A is near enough to excite cell B or repeatedly or persistently takes part in firing it, some growth or metabolic change takes place in both cells such that A's efficiency, as one of the cells firing B, is increased." This idea was imported into cognitive science more broadly, and is popularly paraphrased as "neurons that fire together, wire together" (Wayment et al. 2007). Extended to phonological representations, the connection between representations that co-occur is stronger than any connections that may exist between representations that do not co-occur.

For the purposes of deriving natural classes via feature classes, entailments are argued to arise from the phonological feature specification of cross-linguistically attested phonemes and the phonetic subfeatures that are present in their allophones. Specifically, the phonemes attested in the typological survey in chapter 2 have phonological features and phonetic subfeatures assigned to them (as explained in chapter 4), and it is the co-occurrence of these phonological features and phonetic subfeatures within each phoneme and allophone, respectively, that provides the set of possible entailments in phonological theory. The set of entailments is therefore finite, which restricts the possible ways of unifying segments into natural classes. The set of entailments is also grounded in cross-linguistic phonetic and phonological evidence that motivates particular representations. Entailments, as used in this study, are defined in (94).

(94) Definition of *Entailment*
An *entailment* is a statement of the form $p \rightarrow q$ in which the precondition, *p*, entails the dependent consequent, *q*. The entailment holds true, or is valid, iff:
i. *p* and *q* are non-identical phonological features or phonetic subfeatures, and
ii. *p* and *q* co-occur within a single phoneme attested in at least one language.

Entailments, then, not only relate representational entities of the same type (phonological features or phonetic subfeatures), but relate the different types of representational entities to each other based on their respective relationships to phonemes.[8] This allows several types of explanations for phonological classhood to figure into deriving feature classes. Entailments between only phonological features can encode a purely phonological explanation. Entailments in which phonetic subfeatures entail other subfeatures can express articulatory or acoustic dependencies that are evident within single segments.[9]

Entailments provide a formal means to motivate the co-occurrence of phonemes in a phonological class. The set of entailments is a finite set of connections between phonemes that are defined by the co-occurrence of phonological features and phonetic subfeatures within typologically attested phonemes. This allows the naturalness of phonological classes to be given a non-stipulative explanation and provides a metric for describing the formal complexity of a phonologically active natural class. A phonological class is natural (as opposed to unnatural) if membership in the class is determined solely according to entailments. A phonological class may be more or less complex depending on how many entailments are necessary to define it. For example, a phonological class that can be defined with a single entailment is formally simpler than one which needs to be built using multiple entailments. The complexity metric that arises from the method of deriving natural classes that is proposed here is discussed in further detail in §6.4.

Before going on in §5.4.2.3 to discuss how entailments are used in ASSOCIATE constraints to regulate membership in feature classes, §5.4.2.2 defines feature classes and describes how they differ from more familiar feature bundles.

#### 5.4.2.2 Feature Classes

Feature classes differ from feature bundles in that they are collections of feature bundles that are joined together in a set-theoretic union. Feature bundles each define a set of phonemes in which each phoneme in the set bears all the features in the bundle. Therefore, feature bundles represent the phonemes that lie in the intersection of the set of features that define the bundle. In contrast, a feature class is defined as a union of feature bundles in which all the phonemes in the class must bear the feature specification of at least one of the bundles, but need not bear the feature specifications of all the bundles. (95) provides a definition of a feature class, inspired in part by the discussion of feature classes in Padgett (2002:96).[10]

(95) Definition of a Feature Class:
Where $\text{ʗ}_y$ is a feature class with label $y$, $x_i$ is any bundle of phonological features or pho-

---

[8] For details on these relationships, see §4.4.3.

[9] Another possible basis for entailments, specifically among phonetic subfeatures, are the synergistic relationships between gross states, as detailed in Moisik (2013:627-629, et passim). Many of these relationships are already formally accessible through the co-occurrence of phonetic subfeatures, which has rendered inclusion of the remaining synergistic relationships unnecessary thus far.

[10] The stretched 'c' character (ʗ) stands for the word 'class' in 'feature class' (or, 'natural class') and represents a feature class as an abstract, formally defined set of phonological feature (or phonetic subfeature) bundles. Until 1989, the stretched 'c' was used as the IPA symbol for the alveolar click, but was replaced by the symbol [!] (Pullum and Ladusaw 1996:34). Because the stretched 'c' now has no significance in IPA, it is used here as the symbol for a feature class. The ʗ symbol is also used in set theory to signify the complement of a set, but does not indicate that here.

netic subfeatures, and $|\mathfrak{C}_y| \geq 2$:

$$\mathfrak{C}_y = \{x_1 \cup x_2 \cup \ldots x_n\}$$

Put less formally, a feature class, symbolized $\mathfrak{C}_y$, where $y$ is any label, is a set of two or more bundles of phonological features or phonetic subfeatures (hereafter "feature bundles," symbolized here as $x_i$) which all stand in a union (∪) relationship.[11]

The practical consequence of this difference between feature bundles and feature classes is that as more features (or subfeatures) are added to a feature bundle, fewer phonemes are in the set referred to by the bundle, but as more feature bundles are added to a feature class, more phonemes are in the set referred to by the class. The example in (96) illustrates this using hypothetical features (in Greek letters) and phonemes (in Roman capitals).

(96) Feature Bundles vs. Feature Classes

The table presents hypothetical phonemes with featural representations:

| | α | β | γ | δ |
|---|---|---|---|---|
| A | + | - | - | + |
| B | + | - | - | - |
| C | + | + | - | - |
| D | - | + | + | - |
| E | - | + | + | + |

The feature *bundle* [+α, -δ] is the intersection (∩) of the set of phonemes defined by [+α] and [-δ] ( = /A, C/).

The feature *class* {[+α] ∪ [-δ]} is the union (∪) of the set of phonemes defined by [+α] and [-δ] ( = /A, B, C, D/).

While feature classes are defined by feature bundles, they should be understood as being the union of phonemes that are described by those bundles. Thus, the feature class in (96), {[+α] ∪ [-δ]}, can be interpreted by substituting the feature bundles in the feature class with the phonemes that they represent. In this case, that leaves a set of hypothetical phonemes {{A, B, C} ∪ {B, C, D}}. Combining these sets as a union yields the final set {A, B, C, D}.

Other Optimality Theoretic constraints can refer to feature classes by their label as if that label were itself a (privative) feature. While feature classes are derived in a parallel fashion, their derivation should be understood to take place before the derivations of other processes (or to take priority over those derivations) such that feature classes are available in the derivations of other processes that would refer to them.

[11] The restriction that a feature class include two or more feature bundles need not be stipulated. It will be shown that feature classes that are empty or contain only a single feature are eliminated by ASSOCIATE constraints and MAX-FF$_{\mathfrak{C}}$, respectively.

#### 5.4.2.3 ASSOCIATE Constraints: Using Entailments to Regulate Membership in Feature Classes

The set of entailments provides a source of cross-linguistic explanation for why subsets of phonemes pattern together, but they do not themselves build phonological classes or regulate membership in them in particular languages. To do this, additional theoretical machinery is necessary. This theoretical machinery is a new kind of Optimality Theory (OT; Prince and Smolensky 1993) constraint that enforces the inclusion of bundles of phonological features or phonetic subfeatures (hereafter simply *feature bundles*) in a feature class. A preliminary formal definition for this constraint is given in (97).

(97) ASSOCIATE($\mathcal{C}_i$, $p \rightarrow q$): **(Preliminary; Final definition in (99))**
Where $\mathcal{C}_i$ is a feature class with the label $i$, and $p$ and $q$ are bundles of phonological features or phonetic subfeatures, assign one violation iff:
i. $p \neq q$
ii. $p \in \mathcal{C}_i$
iii. $p \rightarrow q$ is a possible entailment, and
iv. $q$ is not in $\mathcal{C}_i$ such that $\mathcal{C}_i = \{p \cup q\}$

This constraint states that for a candidate feature class $\mathcal{C}_i$ in a derivation, if there are two non-identical feature bundles $p$ and $q$, then if $p$ is already in the feature class and the entailment $p \rightarrow q$ is a possible entailment, then $q$ must be in the candidate feature class. Put more simply, assuming the conditions in i.-iii. in the definition are met, ASSOCIATE constraints assign a violation if the dependent consequent $q$ is not present in a candidate feature class.

Although the ASSOCIATE constraints in their current form perform the main task of deriving feature classes, they do not ensure that a feature class in a given language will contain all and only the feature bundles that represent the phonemes in an attested phonologically active natural class. Three main problems must be solved. First, extraneous feature bundles that function neither in the $p$ nor $q$ roles in the entailments in ASSOCIATE constraints must be ruled out. Otherwise, feature bundles that are not linked to the rest of the feature class via entailments are able to proliferate. Second, not only do extraneous feature bundles need to be ruled out, essential feature bundles (especially those that function as entailment preconditions, $p$) need to be protected from deletion. When precondition features can be deleted without cost, an empty feature class will always vacuously satisfy any ASSOCIATE constraint because if an ASSOCIATE constraint's precondition feature bundle ($p$) is missing, it simply fails to apply and does not assign a violation. The third problem is that the derivation must allow other ASSOCIATE constraints that may exist in the universal constraint set, CON, to be violated so that the size of feature classes can be restricted by the rules of a particular language, not the content of CON. In this section, first, an example derivation is used to illustrate how these problems arise. Then, a solution to each of the three problems stated above is presented.

Suppose that a language has a feature class consisting of phonemes that can be represented with three different feature bundles, [α], [β], and [γ]. The intended output is thus $\mathcal{C}_{Hyp} = \{[\alpha] \cup [\beta] \cup [\gamma]\}$. To derive this output, assume that [α]→[β], [β]→[γ], and [γ]→[δ] are all possible entailments. The constraints ASSOC(ʗ$_{Hyp}$, $[\alpha]\rightarrow[\beta]$) and ASSOC(ʗ$_{Hyp}$, $[\beta]\rightarrow[\gamma]$) use these entailments to derive the intended feature class, but the constraint ASSOC(ʗ$_{Hyp}$, $[\gamma]\rightarrow[\delta]$) also exists in CON. To attempt to negate the effects of this constraint, it is ranked below the constraints that derive the intended feature class. Assume that the input to the derivation is a feature class that consists of $[\alpha]$ and $[\beta]$, which function as preconditions in the entailments in the ASSOCIATE constraints that are needed to derive the intended feature class. In the tableaux here and elsewhere, ASSOCIATE is abbreviated ASSOC and the feature class label is omitted.

(98) Example derivation of a hypothetical feature class with intended output $\{[\alpha] \cup [\beta] \cup [\gamma]\}$

| ʗ = $\{[\alpha] \cup [\beta]\}$ | ASSOC(ʗ, $[\alpha]\rightarrow[\beta]$) | ASSOC(ʗ, $[\beta]\rightarrow[\gamma]$) | ASSOC(ʗ, $[\gamma]\rightarrow[\delta]$) |
|---|---|---|---|
| a. ʗ = $\{[\alpha] \cup [\beta] \cup [\gamma]\}$ | | | 1 |
| 💣 b. ʗ = $\{[\alpha] \cup [\beta] \cup [\gamma] \cup [\delta]\}$ | | | |
| 💣 c. ʗ = $\{[\alpha] \cup [\beta] \cup [\gamma] \cup [\delta] \cup [\epsilon]\}$ | | | |
| d. ʗ = $\{[\alpha] \cup [\beta]\}$ | | 1 | |
| 💣 e. ʗ = $\{[\beta] \cup [\gamma] \cup [\delta]\}$ | | | |
| 💣 f. ʗ = $\{[\delta]\}$ | | | |
| 💣 g. ʗ = $\{\varnothing\}$ | | | |

Candidate (a) is the intended winner, but is eliminated by an ASSOCIATE constraint that should not be relevant because it is lower-ranked. Candidate (b) contains all and only the features called for by the entailments in the ASSOCIATE constraints, and it wins because even though the constraint that is unnecessary for deriving the *intended* feature class is lower-ranked, satisfying it still makes the candidate more harmonic. This illustrates the third problem, which is that the derivation must rule out the addition of some features that is called for by lower-ranked ASSOCIATE constraints.

Candidate (c) also surfaces as optimal because it contains all the same features as candidate (d), thereby satisfying all the ASSOCIATE constraints, but it also contains an additional feature, $[\epsilon]$, that is not called for by any constraint. This illustrates the first problem, which is that extraneous feature bundles need to be ruled out.

Candidate (d) is the fully faithful candidate, and it is eliminated by the second ASSOCIATE constraint because it lacks $[\gamma]$.

Candidate (e) contains only the dependent consequents ($q$) of the entailments in each of the ASSOCIATE constraints, and illustrates the second problem, that precondition features ($p$) can be deleted without penalty. This happens because ASSOCIATE constraints can only assign a violation if the precondition feature bundle, $p$, is present. If there is no $p$, then the ASSOCIATE constraint fails to apply. This is why candidate (f), with a single feature bundle, incurs no violations and also surfaces as optimal, and why candidate (d) does not violate ASSOC(ʗ, $[\gamma]\rightarrow[\delta]$). It is also the reason why candidate (g), which is an empty feature class, is able to surface as optimal. Because it has no feature bundles, it cannot have any precondition feature bundles, and therefore vacuously satisfies any possible ASSOCIATE constraint, including those in (98). The following subsections present solutions to each of these three main problems.

#### 5.4.2.4 Eliminating Extraneous Feature Bundles

The problem with candidate (c) in the example derivation in (98) is that nothing penalizes the feature [ϵ], which is understood to be formally extraneous since it does not fulfill the role of either *p* or *q* in any of the entailments in any of the ASSOCIATE constraints. The extraneous feature [ϵ] occurs in a candidate form in (98c), but could also occur in the input. A faithfulness constraint such as IDENT-IO/OI($F_{\mathcal{C}}$) will not solve these problems unless the input is always held to be the intended feature class. However, under Richness of the Base, all possible inputs must be considered in a derivation, and this forces all possible combinations of feature bundles to be considered as input feature classes. The challenge in any given derivation, then, is to force the necessary feature bundles, i.e. those that function as *p* or *q* in any of the entailments of any of the ASSOCIATE constraints, to be included in candidate feature classes while also preventing the inclusion of extraneous feature bundles. At present, however, there is no formal distinction between these types of features that allows them to be targeted separately by constraints.

The solution proposed here is to modify the definition of the ASSOCIATE constraints to cause them to formally identify these feature bundle types in candidates. The ASSOCIATE constraints already distinguish these types of feature bundles, i.e. those that function as *p* or *q* from those that are extraneous. The problem is making these identifications available to other constraints. The ASSOCIATE constraints already identify and enforce the inclusion of *q* in feature classes, so the task is to maintain the inclusion of *p* feature bundles while also eliminating extraneous features. This can be done by modifying the definition of the ASSOCIATE constraints such that they promote the establishment of a formal correspondence relationship between the *p* and *q* feature bundles in each candidate feature class. The entailment in each ASSOCIATE constraint already establishes a formal relationship between *p* and *q*, provides the basis for a correspondence relationship. Putting the *p* and *q* feature bundles into a formal correspondence relationship using the ASSOCIATE constraints ensures that only the feature bundles that are relevant in the derivation will correspond, and this uniquely identifies them to the exclusion of extraneous feature bundles, which can then be targeted for deletion.

The redefinition of ASSOC($\mathcal{C}_i$, $p \rightarrow q$), which incorporates the establishment of a correspondence relationship between feature bundles that function as *p* and *q*, is given in (99).

(99) ASSOCIATE($\mathcal{C}_i$, $p \rightarrow q$): **(Preliminary Version 2)**
Where $\mathcal{C}_i$ is a feature class with the label *i*, and *p* and *q* are bundles of phonological features or phonetic subfeatures, assign one violation iff:
- i. $p \neq q$
- ii. $p \in \mathcal{C}_i$
- iii. $p \rightarrow q$ is a valid entailment,
- iv. a correspondence relation obtains between *p* and *q*, and
- v. *q* is not in $\mathcal{C}_i$ such that $\mathcal{C}_i = \{p_1 \cup q_1\}$

With this redefinition, the feature bundles *p* and *q* are now in a correspondence relationship, and a violation is assigned if the dependent consequent feature bundle, *q*, is not present.[12]

[12]A separate constraint, such as CORR-$FF_{\mathcal{C}_i}$, could not assign the correspondence relationship to the *p* and *q*

Because the feature bundles that are extraneous can now be identified to the exclusion of necessary feature bundles, constraints can target those extraneous feature bundles for deletion. The constraint that penalizes these extraneous feature bundles does so by penalizing the fact that they are not in a correspondence relationship. This constraint is MAX-FF$_{\mathfrak{C}}$, which is defined in (100) and is inspired by MAX-CC in McCarthy (2010:3).

(100) MAX-FF$_{\mathfrak{C}}$:
Assign one violation for every feature bundle (i.e. a bundle of phonological features or phonetic subfeatures) that is in a feature class, $\mathfrak{C}$, and is not in a correspondence relationship with another feature bundle within that feature class.

This constraint assigns a violation for any feature bundle in a candidate feature class that is not in a correspondence relationship, and is therefore able to delete extraneous feature bundles that are not required by any of the ASSOCIATE constraints.

The example derivation in (101) shows that candidate (b) is eliminated, but that problematic candidates still remain.

(101) Example derivation of a hypothetical feature class with intended output $\{[\alpha] \cup [\beta] \cup [\gamma]\}$

| | $\mathfrak{C} = \{[\alpha] \cup [\beta]\}$ | MAX-FF$_{\mathfrak{C}}$ | ASSOC($\mathfrak{C}$, $[\alpha]\to[\beta]$) | ASSOC($\mathfrak{C}$, $[\beta]\to[\gamma]$) | ASSOC($\mathfrak{C}$, $[\gamma]\to[\delta]$) |
|---|---|---|---|---|---|
| a. | $\mathfrak{C} = \{[\alpha]_1 \cup [\beta]_{1,2} \cup [\gamma]_2\}$ | | | | 1 |
| 💣 b. | $\mathfrak{C} = \{[\alpha]_1 \cup [\beta]_{1,2} \cup [\gamma]_{2,3} \cup [\delta]_3\}$ | | | | |
| c. | $\mathfrak{C} = \{[\alpha]_1 \cup [\beta]_{1,2} \cup [\gamma]_{2,3} \cup [\delta]_3 \cup [\epsilon]\}$ | 1 | | | |
| d. | $\mathfrak{C} = \{[\alpha]_1 \cup [\beta]_1\}$ | | | 1 | |
| 💣 e. | $\mathfrak{C} = \{[\beta]_1 \cup [\gamma]_{1,2} \cup [\delta]_2\}$ | | | | |
| f. | $\mathfrak{C} = \{[\delta]\}$ | 1 | | | |
| 💣 g. | $\mathfrak{C} = \{\varnothing\}$ | | | | |

This tableau shows that candidate (c) has been eliminated by MAX-FF$_{\mathfrak{C}}$, which assigned a violation because the feature bundle $[\epsilon]$ has no corresponding feature bundle. In addition, candidate (f) with only a single feature bundle is also eliminated because if only one feature bundle exists, it cannot have a correspondent. Thus, classes with only one feature bundle are systematically suboptimal when MAX-FF$_{\mathfrak{C}}$ is highly ranked.

While feature bundles that function as preconditions in the ASSOCIATE constraints are preserved where they exist, their existence is not ensured, as the optimality of candidate (e), which lacks $[\alpha]$, attests. The next section turns to ensuring that precondition feature bundles are always present.

segments since any constraint other than an ASSOCIATE constraint cannot access the identity of the roles that each feature bundle plays with respect to each ASSOCIATE constraint.

#### 5.4.2.5 Ensuring the Presence of Precondition Feature Bundles

Candidate (e) contains the dependent consequents ($q$, i.e. [β], [γ], and [δ]) for both ASSOCIATE constraints, but is missing the precondition ($p$, i.e. [α]) for the first associate constraint, ASSOC(Ꞓ, [α]→[β]), even though it was present in the input. In candidate (e), both feature bundles are in a correspondence relationship (established by the constraint ASSOC(Ꞓ, [β]→[γ])) and ASSOC(Ꞓ, [α]→[β]) fails to apply since [α] is not present. The fact that candidate (e) is not the intended output, but nevertheless surfaces as optimal, shows that precondition feature bundles can sometimes be deleted without consequence.

While faithfulness to the input via a constraint like MAX-IO(F) would ensure that precondition feature bundles would appear in output forms, it would only do so if the precondition feature bundle already appeared in the input. Given Optimality Theory's principle of Richness of the Base, in which all possible inputs must be considered (Prince and Smolensky 1993:209), restricting the input is impossible, and therefore a solution that relies on input faithfulness like MAX-IO(F) is untenable.

The solution capitalizes on the co-occurrence basis of entailments. According to the Representational Entailment Hypothesis, stated in (93), the co-occurrence of features, such as A and B, forms the basis for not one entailment, but two: A→B and B→A. This means that if an entailment in one direction, e.g. A→B, is valid, then so is its counterpart in the other direction, B→A. This fact can be incorporated into the definition of the ASSOCIATE constraints to penalize not only the absence of the dependent consequent, $q$, but the precondition, $p$. The redefinition of the ASSOCIATE constraints to incorporate this fact is given in (102).

(102) ASSOCIATE(Ꞓ$_i$, $p \leftrightarrow q$): **(Final Definition)**

Where Ꞓ$_i$ is a feature class with the label $i$, and $p$ and $q$ are bundles of phonological features or phonetic subfeatures, iff:

i. $p \neq q$
ii. $p \rightarrow q$ and $q \rightarrow p$ are valid entailments, and
iii. a correspondence relation obtains between $p$ and $q$,

then assign one violation for each case in which:

a. $p$ is not in Ꞓ$_i$ such that Ꞓ$_i$ = $\{p_1 \cup q_1\}$, or
b. $q$ is not in Ꞓ$_i$ such that Ꞓ$_i$ = $\{p_1 \cup q_1\}$

This redefinition of the ASSOCIATE constraints assigns one violation for the absence of $p$ and one violation for the absence of $q$. This obviates the need for the condition that $p$ already be present in the feature class being derived. Enforcing the presence of $p$ regardless of the input allows the principle of the Richness of the Base to be maintained, but renders faithfulness to the input unnecessary. Because the ASSOCIATE constraints exist independently of the input and enforce the inclusion of the feature bundles in the entailments that they contain, the content of the input for any given derivation does not matter.

The redefinition of the ASSOCIATE constraints ensures that both feature bundles that are called for must be present. This eliminates candidates without those features, including empty feature classes that lack all features, as in candidate (g). The tableau in (103) illustrates this.

(103) Example derivation of a hypothetical feature class with intended output $\{[\alpha] \cup [\beta] \cup [\gamma]\}$

| | Ꞓ = $\{[\alpha] \cup [\beta]\}$ | MAX-FF$_{Ꞓ}$ | ASSOC(Ꞓ, $[\alpha]\leftrightarrow[\beta]$) | ASSOC(Ꞓ, $[\beta]\leftrightarrow[\gamma]$) | ASSOC(Ꞓ, $[\gamma]\leftrightarrow[\delta]$) |
|---|---|---|---|---|---|
| a. | Ꞓ = $\{[\alpha]_1 \cup [\beta]_{1,2} \cup [\gamma]_2\}$ | | | | 1 |
| 💣 b. | Ꞓ = $\{[\alpha]_1 \cup [\beta]_{1,2} \cup [\gamma]_{2,3} \cup [\delta]_3\}$ | | | | |
| c. | Ꞓ = $\{[\alpha]_1 \cup [\beta]_{1,2} \cup [\gamma]_{2,3} \cup [\delta]_3 \cup [\epsilon]\}$ | 1 | | | |
| d. | Ꞓ = $\{[\alpha]_1 \cup [\beta]_1\}$ | | | 1 | 2 |
| e. | Ꞓ = $\{[\beta]_1 \cup [\gamma]_{1,2} \cup [\delta]_2\}$ | | 1 | | |
| f. | Ꞓ = $\{[\delta]\}$ | 1 | 2 | 2 | 1 |
| g. | Ꞓ = $\{\varnothing\}$ | | 2 | 2 | 2 |

In this tableau, candidate (e), which contained only what were formerly dependent consequents (*q*), is now eliminated because the ASSOCIATE constraints enforce the presence of both feature bundles in their entailments, and $[\alpha]$ is absent.

The feature class that surfaces as optimal, candidate (b), is now the unique winner, but it is not the intended winner. Constraint ranking alone does not prevent lower-ranking ASSOCIATE constraints from deciding the winner. What is needed is a constraint to countervail the influence of these lower-ranking ASSOCIATE constraints.

#### 5.4.2.6 Regulating Membership in Feature Classes Within a Language

The set of entailments is derived from the co-occurrence of elements of featural representation (i.e. phonological features and phonetic subfeatures) within each cross-linguistically attested phoneme.[13] Any of these entailments can, in principle, occur in an ASSOCIATE constraint. If the constraint set in Optimality Theory, CON, is universal, then every ASSOCIATE constraint used by a given language exists for every other language. However, not every language uses the same feature classes, so some derivational mechanism must be able to model how this occurs. The method proposed for deriving language-specificity, given a universal constraint set, is to rank the active ASSOCIATE constraints above a countervailing constraint that is in turn ranked above every other ASSOCIATE constraint that is not active in a language.

The countervailing constraint that negates the influence of lower-ranked ASSOCIATE constraints is DEP-FF$_{Ꞓ}$, which is the counterpart to MAX-FF$_{Ꞓ}$, and is defined in (104).

(104) DEP-FF$_{Ꞓ}$:
Assign one violation for every feature bundle (i.e. a bundle of phonological features or

[13]The phonological feature representation of each phoneme is assumed to be universal because it is motivated by cross-linguistically possible contrasts. Therefore, each phoneme, for example /q/, is assumed to have the same phonological feature representation in each language in which a phoneme /q/ occurs. Language-specificity is captured by phonetic subfeatures, which are associated with that phoneme's allophones (including its principal or only allophone).

phonetic subfeatures) that is in a feature class, $\mathcal{C}$, and is in a correspondence relationship with another feature bundle within that feature class.

This constraint penalizes the correspondence relationships that are set up by ASSOCIATE constraints, including both the active and inactive ASSOCIATE constraints in a given language. However, ranking it between the active and inactive ASSOCIATE constraints means that it is better to violate DEP-FF$_{\mathcal{C}}$ than the active ASSOCIATE constraints, and better to violate the inactive ASSOCIATE constraints than DEP-FF$_{\mathcal{C}}$. This means that optimal forms will not violate active ASSOCIATE constraints and will readily violate inactive ASSOCIATE constraints in order to satisfy DEP-FF$_{\mathcal{C}}$. The tableau in (87) shows how DEP-FF$_{\mathcal{C}}$ and its ranking are able to derive the intended feature class in candidate (a) while eliminating the feature class in candidate (b) that satisfies every ASSOCIATE constraint.

(105) Example derivation of a hypothetical feature class with intended output $\{[\alpha] \cup [\beta] \cup [\gamma]\}$

| $\mathcal{C} = \{[\alpha] \cup [\beta]\}$ | MAX-FF$_{\mathcal{C}}$ | ASSOC($\mathcal{C}$, $[\alpha]\leftrightarrow[\beta]$) | ASSOC($\mathcal{C}$, $[\beta]\leftrightarrow[\gamma]$) | DEP-FF$_{\mathcal{C}}$ | ASSOC($\mathcal{C}$, $[\gamma]\leftrightarrow[\delta]$) |
|---|---|---|---|---|---|
| → a. $\mathcal{C} = \{[\alpha]_1 \cup [\beta]_{1,2} \cup [\gamma]_2\}$ | | | | 3 | 1 |
| b. $\mathcal{C} = \{[\alpha]_1 \cup [\beta]_{1,2} \cup [\gamma]_{2,3} \cup [\delta]_3\}$ | | | | 4! | |
| c. $\mathcal{C} = \{[\alpha]_1 \cup [\beta]_{1,2} \cup [\gamma]_{2,3} \cup [\delta]_3 \cup [\epsilon]\}$ | 1! | | | 4 | |
| d. $\mathcal{C} = \{[\alpha]_1 \cup [\beta]_1\}$ | | | 1! | 2 | 2 |
| e. $\mathcal{C} = \{[\beta]_1 \cup [\gamma]_{1,2} \cup [\delta]_2\}$ | | 1! | | 3 | |
| f. $\mathcal{C} = \{[\delta]\}$ | 1! | 2 | 2 | | 1 |
| g. $\mathcal{C} = \{\varnothing\}$ | | 2! | 2 | | 2 |

#### 5.4.2.7 Constraint Ranking

Tableau (105) showed the motivation for the overall constraint ranking in (106) that correctly derives natural classes as feature classes.

(106) Constraint schema for deriving natural classes in any given language

MAX-FF$_{\mathcal{C}}$, Active ASSOC($\mathcal{C}_i$, $p\leftrightarrow q$) constraints $\gg$
DEP-FF$_{\mathcal{C}}$ $\gg$
Inactive ASSOC($\mathcal{C}_i$, $p\leftrightarrow q$) constraints

This ranking is able to derive natural classes as a set (a feature class) that is the union of the phonemes represented by the feature bundles that are specified by the entailments in the active ASSOCIATE constraints. Because DEP-FF$_{\mathcal{C}}$ penalizes the correspondence relationships that are set up by satisfying the inactive ASSOCIATE constraints, only the active ASSOCIATE constraints, which are those that are ranked above DEP-FF$_{\mathcal{C}}$, are able to influence the composition of a given feature class in a language.

## 5.5 Predictions

The account presented here for the derivation of phonologically active classes makes several predictions. The first is that unnatural classes should each occur in only one language. This is because unnatural classes are derived here, following Flemming (2005), as the byproduct of the interaction of Optimality Theory constraints. Because languages are predicted to differ by ranking these constraints differently, unnatural classes should occur only in one language. Although it is possible for two languages to have the same constraint ranking, this is unlikely, and thus unnatural classes should only rarely occur for two or more languages. The probability of unnatural classes occurring in more than one language should correlate with the rate at which languages share a constraint ranking. If an unnatural class occurred in many more languages than expected, it would indicate that the class may actually be natural. For example, it may be that there is a phonetic explanation that has been overlooked or that cognitive factors may be at play. In this respect, the prevalence of a class that appears to be highly phonetically unnatural could be a way of finding analytic bias (Moreton 2008). Another possibility is that the recurrence of unnatural classes is an artifact of the recurrence of natural classes to which regular diachronic processes have applied.

The second prediction is that the set of possible entailments should allow for the derivation of all natural classes, but not for the derivation of unnatural classes. The set of possible entailments can be derived from the co-occurrence of phonological features and phonetic subfeatures within each cross-linguistically attested phoneme. Because natural classes are derived using these entailments, they should be able to be used to derive every phonological class that is judged to be natural. Unnatural classes are predicted to be unnatural because they are unable to be derived using entailments. Therefore, counter-evidence to the approach pursued here would be the ability to consistently derive unnatural classes using entailments, causing over-generation.[14] Conversely, if many natural classes cannot be derived using entailments, this is also counter-evidence for the approach proposed here, and represents a case of under-generation and descriptive inadequacy. Given the large number of entailments that are possible to derive from the diverse representations of attested phonemes, it seems more likely that counter-evidence will come in the form of over-generation and that the space of entailments that can be used will have to be restricted.

The third prediction is that the entailments that are needed for deriving the most attested natural classes found in the world's languages will demonstrate which connections between phonemes are most salient in language generally. This prediction could be evaluated experimentally, for example through artificial grammar learning experiments in which bias toward the most frequently necessary entailments is able to be detected.

[14] One approach to restricting such overgeneration may be to impose a restriction in some form that ensures that the entailments in active ASSOCIATE constraints must be linked. For example, instead of allowing the active ASSOCIATE constraints to include ASSOC(ʗ, A↔B) and ASSOC(ʗ, D↔E), a restriction could require entailment chaining such that those two constraints could only be included if ASSOC(ʗ, B↔C) and ASSOC(ʗ, C↔D) were also present.

## 5.6 Summary and Conclusion

In this chapter, a relatively theory-neutral typology of phonological classes was presented to establish working terminology for discussing phonological classhood. This terminology was used to compare previous conceptions of what a "natural class" is and how phonological theory should account for generalizations about phonological classhood. It was shown that representational approaches are generally too inflexible to account for all phonological classes that have a phonetic basis. Feature Class Theory provided a bridge between the representational account of phonological classes from Feature Geometry and the derivational machinery of Optimality Theory, but was still essentially representational and lacked a means for deriving feature classes. While Flemming (2005) presented a method of deriving phonologically active classes from constraint interaction, that method failed to categorically differentiate natural from unnatural classes (in the terminology of this study) and to make predictions about the commonality of certain phonological classes over others cross-linguistically.

In this chapter, I proposed a new framework for deriving phonologically active natural classes. In this framework, the co-occurrence of phonological features or phonetic subfeatures in cross-linguistically attested phonemes provide the basis for (symmetrical) phonological entailments. These entailments individually state that if one representational entity, *p*, is present, then another representational entity, *q*, must also be present. A new type of OT constraint, the ASSOCIATE constraints, use two symmetrical entailments to regulate phonemes' membership in feature classes. They also establish a formal correspondence relationship based on their entailments, and this is used to further regulate membership in the feature class through the MAX-FF$_{\mathfrak{C}}$ and DEP-FF$_{\mathfrak{C}}$ constraints. MAX-FF$_{\mathfrak{C}}$ is undominated and penalizes formally extraneous features that are not required by any ASSOCIATE constraint. DEP-FF$_{\mathfrak{C}}$ penalizes feature bundles that are in the correspondence relationships established by the ASSOCIATE constraints and thereby countervails their power to include feature bundles in a feature class. By ranking ASSOCIATE constraints with respect to DEP-FF$_{\mathfrak{C}}$, the composition of a feature class can be regulated on a language-specific basis.

The framework proposed here improves on other methods of accounting for phonological natural class behavior within phonological theory. First, it allows for phonologically active classes to be derived, as Flemming (2005) did, but formally distinguishes between natural and unnatural classes. Because unnatural classes arise epiphenomenally as a result of constraint interaction and because typological differentiation has been proposed to arise from differences in constraint ranking in each language (Prince and Smolensky 1993:27), this account predicts that each unnatural class will be language-specific and typologically extremely rare, if not unique.

Second, the framework that I propose here for deriving phonologically active natural classes formally incorporates phonetic explanation by using entailments. Entailments are based on the co-occurrence of phonological features or phonetic subfeatures in phonemes that have been attested in the world's languages based on the idea that this co-occurrence implies an underlying connection. This underlying connection is taken here to be the phonetic or cognitive factors that predispose the co-occurrence of two bundles of phonological features or phonetic subfeatures, and this predisposition forms the basis for the "naturalness" of two groups of phonemes acting together as a phonological class.

As a final note, this chapter has focused only on deriving hypothetical natural classes. The next chapter, §6, demonstrates how the framework presented here can be used to derive phonological classes composed of post-velar consonants, including Arabic's guttural natural class. In the derivations of those classes, the entailments that motivate the inclusion of features in a particular natural class are motivated by experimentally observed phonetic connections.

# Chapter 6

# Deriving Post-Velar Natural Classes

## 6.1 Introduction

The guttural natural class has been proposed to exist as an innate component of phonological grammar by McCarthy (1994) and to encompass the uvular, pharyngeal, and glottal consonants. However, in languages that have been claimed to show evidence for the guttural natural class, membership in that class varies cross-linguistically and even within a single language. For example, glottals are claimed not to participate in the post-velar phonological class in the Interior Salish languages (Bessell 1992; cf. Rose 1996), even though they are observed as participating in the guttural natural class in other languages, such as Arabic. In addition, phonemes (e.g. uvulars) can behave ambivalently, showing evidence for membership in two phonological classes (dorsal and guttural). Finally, despite well-attested phonological evidence, phonetic and phonological experimental investigation has failed to discover a single phonetic correlate that could be used as a unifying characteristic for the class. This is problematic since other observed phonological classes, especially those that are place-of-articulation-based, like Labial, Coronal, and Dorsal, can be said to cohere because of a specific phonetic property that unifies them, such as an active articulator.

This variability and lack of a single unifying phonetic characteristic gives reason to question whether the guttural natural class is innate and universal, as proposed by McCarthy (1994:203). §6.2 addresses this question, and argues that the approach explained in chapter 5 is better suited to deriving the attested data on phonological classes composed of post-velar consonants. The next section, §6.3 presents derivations of phonologically active natural classes composed of various combinations of post-velar consonants. §6.3 ends with a derivation of the guttural natural class as it exists in Arabic. Before concluding the chapter in §6.5, §6.4 discusses the question of how the new framework assesses the "naturalness" of a feature class (i.e. a phonologically active natural class).

## 6.2 Evaluating the Guttural Natural Class: Evidence for Emergent Natural Classes

To determine whether generalizations about phonologically active classes are captured more accurately by deriving them from phonetic connections between phonemes (as proposed here) or by referencing a pre-defined abstract representational structure, it is necessary to sample a large number of phonological classes. Because this study focuses on post-velar consonants, only their patterning in phonological classes is examined here.

The proposal advanced in chapter 5 is that phonologically active natural classes are derived based on phonetic connections between phonemes that are manifested in the co-occurrence of phonological features and phonetic subfeatures within phonemes that are attested in the world's languages. This proposal predicts that specific phonetic connections between phonemes will influence how subsets of those phonemes pattern together in phonological classes. Phonemes with stronger connections are expected to be more likely to pattern together than those with weaker connections.

Hayward and Hayward (1989) and McCarthy (1991, 1994) argue that the post-velar consonants, which include the uvulars, pharyngeals, and glottals, form the guttural natural class. The evidence that they cite for the guttural natural class comes from Semitic and Cushitic languages and includes phonological processes and distributional constraints that require referencing the post-velar consonants as a phonologically active class.[1] McCarthy (1994:203) explicitly claims that the guttural natural class is innate (and therefore universal). This leads to the prediction that if the phonemes that are proposed to belong to the guttural natural class are present in a language, any subset of those phonemes should be equally likely to pattern together as members of that class.

### 6.2.1 Testing Predictions with *P-base*

To test the prediction of the derivational approach proposed here that more similar post-velar phonemes (i.e. those with phonetic connections, and therefore entailments, between them) will pattern together against the prediction that all post-velar phonemes are equally likely to pattern together based on their membership in an innate guttural natural class, this study queried *P-base* (Mielke 2008), a database listing phonemic inventories, phonological processes, and distributional constraints from 628 language varieties.[2,3] Languages were surveyed for phonological processes

[1]The specific evidence cited includes a variety of processes and constraints that either actively lower vowels to /a/ or preserve an occurrence of /a/ adjacent to post-velars in many languages, root co-occurrence constraints in Arabic and Qafar, transguttural harmony in Jibbāli, a prohibition on stressing a vowel that precedes a post-velar in Jibbāli, and a prohibition on post-velars occurring in coda position or geminating in Tiberian Hebrew and Tigré, among other processes.

[2]This corresponds to approximately 549 distinct languages according to the divisions in Ethnologue (Lewis 2009). Throughout this section, "languages" should be understood as referring to *P-base* language varieties.

[3]Most of this section (§6.2.1) appeared in: Sylak-Glassman, John. 2014. "An Emergent Approach to the Guttural Natural Class." Supplemental Proceedings of the 2013 Annual Meeting on Phonology, ed. by John Kingston, Claire Moore-Cantwell, Joe Pater, and Robert Staubs. Linguistic Society of America: Washington, DC. The author holds the

or distributional constraints (i.e. sound patterns) that referred to groupings which included primarily post-velars as targets or triggers.[4] This was done to find the phonologically active classes in which post-velars participate to see whether these classes were composed of more similar post-velar consonants, which is consistent with the derivational approach, or of post-velar consonants without regard to similarity beyond that designation, which is consistent with the presence of an innate guttural natural class that includes all post-velar consonants.

To determine the contributions of consonants at each post-velar articulation to phonological processes in which multiple post-velar places of articulation are involved, languages with only a single post-velar place of articulation were surveyed for processes in which post-velar consonants caused changes in vowel quality, such as lowering and backing, that are attested with post-velar consonants that are claimed to act as members of the guttural natural class in sources such as Hayward and Hayward (1989) and McCarthy (1991, 1994). This helps to establish the extent to which the independent effects of consonants at each post-velar place of articulation can be expected to contribute to phonological effects.

In querying *P-base*, 3 languages (23%) of the 13 that have uvulars as their only post-velar consonants show lowering or backing effects on vowels. Only one language, Northern Talysh (Indo-European) was listed as containing a pharyngeal consonant, but no uvulars or glottals.[5] However, no phonological effects of this consonant were noted for Northern Talysh in the database or the original source. Out of the 396 languages that have glottals as their only post-velar consonants, only one language, Amharic (Semitic), shows effects that suggest that glottals are members of an innate natural class and behave as such, even in the absence of other post-velar consonants. Amharic's sole post-velar consonant, glottal /h/, usually neutralizes the vocalic opposition /ə/ vs. /ɐ/ in favor of lower /ɐ/. However, Hayward and Hayward (1989:179-180, 190) show that these effects can be attributed entirely to the fact that most tokens of contemporary /h/ derive from a historical merger of **χ, *ħ, *h* > *h*. Other tokens of /h/ in Amharic result from another sound change (**k* > *h*) in which /h/ does not originate from a post-velar consonant, and these tokens of /h/ do not neutralize the distinction between /ə/ and /ɐ/. The results of surveying languages with post-velar consonants at only a single place of articulation are shown in Table 6.1.

copyright for this work.

[4]A majority, but not all, post-velars were required to participate in these sound patterns for them to count as evidence of the guttural natural class. For example, a process in which uvulars and pharyngeals, but not glottals, cause vowel quality changes would be counted as evidence since the majority of post-velars participated in the process.

[5]The source used in *P-base*, Schulze (2000), is based on data from a single text given by one informant (5). The only description given of the consonant is its category label, 'pharyngeal,' and its transcription as "*h* /h/" (9). This leaves open the possibility that the consonant is actually glottal. Note that there is only one certain attestation of a language, Minyanka (Senufo), that contains a pharyngeal, but no other post-velars.

| *Place of Articulation* | Uvular | Pharyngeal | Glottal |
|---|---|---|---|
| *Lowering/Backing Effects* | 3 (23%) | 0 (0%) | 1 (0.25%) |
| *No Effects on Vowels* | 10 | 1 | 395 |
| *Total Languages* | 13 | 1 | 396 |

Table 6.1: Lowering or backing effects by post-velars in languages with post-velar consonants at only one place of articulation.

Since the effects that have been surveyed so far occur with consonants at only a single place of articulation, they cannot be unambiguously attributed to a phonological class (such as the gutturals) since the effects can be interpreted as characteristic of that particular place of articulation alone. However, with two post-velar places of articulation, it allows for the possibility that sound patterns could refer to both places of articulation and thereby provide evidence for whether a phonologically active post-velar class should be derived or is innate.[6] At this point, it is useful to review the predictions of the two hypotheses under evaluation. The derivational approach predicts that the more similar phonemes will pattern together and that less similar phonemes will be less likely to pattern together. The proposal that there is an innate guttural natural class, which encompasses three places of articulation, predicts that any phonemes within that class have an equal likelihood of patterning together.

The results of querying *P-base* show that the likelihood of all post-velar consonants patterning together is not equal. Of the 58 languages in *P-base* that contain uvulars and glottals but no pharyngeals, only 2 (3.44%; Misantla Totonac and the Samish dialect of Straits Salish) show effects in which the two places of articulation pattern together. However, in languages with pharyngeals and at least one other post-velar place of articulation, there appears to be a greater likelihood that there will be evidence for a phonologically active post-velar class. Two of the 10 languages (20%) with pharyngeals and glottals, but no uvulars, show evidence for a phonologically active post-velar class, and 3 of the 17 languages (17.65%) with all three post-velar places of articulation show such evidence. This evidence suggests that in the absence of pharyngeal consonants, phonologically active post-velar classes are less likely to be observed.

[6]Throughout the rest of this section, the term “phonologically active post-velar class” will be used to signify a phonologically active class in which post-velar consonants comprise the majority of segments involved without committing to the “naturalness” of the class according to any particular theory.

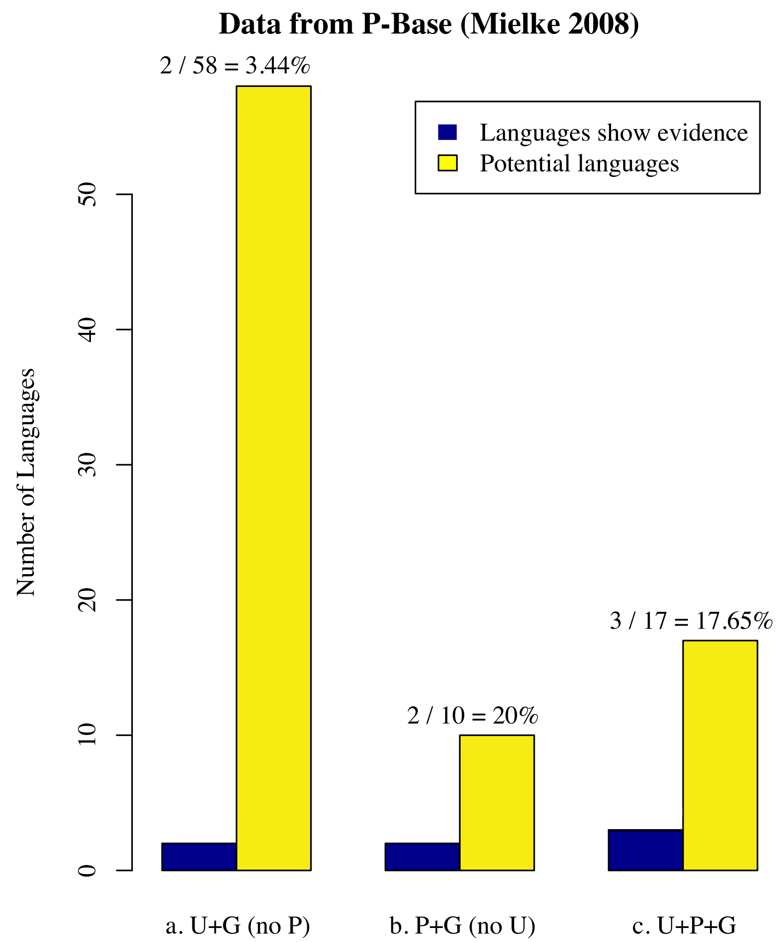


Figure 6.1: Languages with consonants at certain post-velar places of articulation, divided into those that show evidence for a phonologically active class composed of post-velar consonants (blue) and those that do not (yellow) based on evidence from P-Base. Mielke (2008)

Logistic regression analysis on the data in Figure 6.1 shows this to be true. The logistic regression analysis modeled the likelihood that languages with a particular combination of places of articulation would show evidence of a phonologically active post-velar class by using the presence of each post-velar place of articulation as main factors. Modeling the likelihood of a language showing evidence of a phonologically active post-velar class was done using the generalized linear model Likelihood $\sim$ Uvular * Pharyngeal * Glottal in *R* (R Core Team 2013). Because the factor Glottal never varied (i.e. glottal consonants were present in every process that provided evidence for a phonologically active post-velar class), this factor was discarded from the analysis, yielding the model Likelihood $\sim$ Uvular * Pharyngeal. A stepwise evaluation of this model revealed that having a pharyngeal consonant (Pharyngeal) was a significant factor ($p < 0.05$). The results of an ANOVA using the $\chi^2$ test on the final model, Likelihood $\sim$ Pharyngeal * Uvular, are presented in Table 6.2.

| | DF | Deviance | Resid. DF | Resid. Dev. | P(>\|χ\|) | |
|---|---|---|---|---|---|---|
| NULL | | | 84 | 48.361 | | |
| Pharyngeal | 1 | 5.0870 | 83 | 43.274 | 0.02411 | * |
| Uvular | 1 | 0.0229 | 82 | 43.251 | 0.87966 | |
| Phar:Uv | | 0 | 82 | 43.251 | | |

Table 6.2: ANOVA using the $\chi^2$ test on the final model, Likelihood $\sim$ Pharyngeal * Uvular

These results support the idea that the presence of pharyngeals increases the likelihood of the appearance of evidence of a phonologically active post-velar class. From the results for single post-velar places of articulation, laid out in Table 6.1, it is unexpected that glottals would increase the likelihood of finding evidence for a phonologically active post-velar class, but from those same results, it is expected that uvulars would have the potential to increase the likelihood of finding such evidence. This does not seem to occur, though, since when only uvulars and glottals are present, the likelihood of finding evidence for a phonologically active post-velar class is very low.

It is unexpected that the presence of pharyngeal consonants would increase the likelihood of the occurrence of surface evidence of a phonologically active post-velar class. If there is an innate guttural natural class that includes all three post-velar places of articulation, the expectation is that if any two of the three places of articulation are present, sound patterns should be equally likely to reference those two places together. It may be contended that the uvulars' ability to pattern with the velars as dorsals and the glottals' ability to pattern independently may make them less likely to pattern phonologically as gutturals. However, if there is an innate guttural natural class, the presence of any two of the three post-velar places of articulation should increase the likelihood of the occurrence of phonological processes that refer to the segments at those two places of articulation, no matter their specific identities. The fact that the specific identities of segments and their places of articulation do matter points to the special status of pharyngeals in providing surface evidence for a phonologically active post-velar class. This is unexpected under the hypothesis of an innate guttural natural class, and suggests that there is a different explanation.

This study argues, therefore, that specific phonetic and phonological similarities between the pharyngeals and uvulars as well as between the pharyngeals and glottals are responsible for the distribution of evidence for phonologically active classes of post-velar consonants that has been shown in this section.

## 6.3 Deriving Attested Post-Velar Natural Classes

The results of querying *P-base* showed that the identity, specifically the place of articulation, of phonemes influences the likelihood that they will pattern together as a phonologically active class. This goes against the expectations that arise from positing innate, pre-specified natural classes, and suggests that an approach that derives phonologically active classes based on phonetic and phonological similarity will provide a better fit to the observed data and yield a more principled explanation for why segments pattern together as they do.

With the theoretical mechanism for deriving natural classes established in chapter 5, this section exemplifies the derivation of representative types of post-velar natural classes discussed in chapter 2. This section starts with a discussion of how uvulars, pharyngeals, and glottals are each represented using examples from Aymara, Avar, and Kashaya.

The section goes on to exemplify the derivation of phonological classes composed of combinations of these post-velar places of articulation, namely pharyngeals and glottals in Tiberian Hebrew (§6.3.3), pharyngeals and uvulars in Coeur d'Alene (§6.3.4), and uvulars and glottals in Filomeno Mata Totonac (§6.3.5). This section concludes with a derivation of the well-known guttural natural class as it occurs in Arabic (§6.3.6). For each phonological class, the phonetic links between the phonemes involved are explained, followed by a discussion of how these links are formalized as entailments.

### 6.3.1 Single Post-Velar Places of Articulation

In Aymara (Jaqi), the high vowels /i/ and /u/ lower to [e∼ɛ] and [o], respectively, in contact with uvulars (Hardman et al. 1988:32-38). The data in (13) and (15) show that /i/ and /u/ lower to [ɛ] and [ɔ], respectively, adjacent to uvulars, but not velars or glottals. The uvulars in Aymara are /q, $q^h$, q'/ and /χ/. The uvulars can be separated from the glottals representationally with [+raised], and from the velars with the additional feature [+open], which yields the feature bundle [+raised, +open] for uvulars.[7]

In Avar (Nakh-Daghestanian), the pharyngeal consonants, to the exclusion of other consonants, cause fronting of /o/ and /u/ to [ø] and [y], respectively, as shown in (33). The pharyngeals in Avar, /ħ, ʕ/, can be represented using a single feature as [+ce]. Their fronting effect can be attributed to their "double bunching" articulation, which produces anterior and posterior lingual constrictions, in addition to the epilaryngeal constriction. This articulation is associated with the primary allophone of each Avar pharyngeal consonant, and can be symbolized with the phonetic subfeature {**dbe**}.

Kashaya exhibits laryngeal transparency in which vowels must be identical when separated only by a glottal consonant. Examples of this are shown in (65). In laryngeal transparency, the glottals pattern together to the exclusion of all other consonants. The glottals are therefore a phonologically active class, and arguably a natural one since they have an active articulator in common. However, in contrast to the uvulars and pharyngeals, this common articulation is not reflected in their featural representation. Instead, they are represented negatively with the feature bundle [-front, -raised, -ce], which reflects the fact that they are not articulated with the tongue nor with epilaryngeal constriction.[8]

---

[7]For details on the phonetic justification of the particular features chosen for post-velar consonants, see §4.4.2.1.

[8]Note that glottal stop (/ʔ/), but not /h/, does often involve some epilaryngeal articulation in the form of ventricular incursion (Moisik 2013:77-79 and p.c.), i.e. the raising of the larynx can bring the glottis into contact with the ventricular folds.

### 6.3.2 Multiple Post-Velar Places of Articulation

Although each post-velar place of articulation can be represented using a feature bundle, combinations of the post-velar places of articulation cannot be represented that way. Because combining features into larger bundles will only narrow the range of segments that are described by that bundle, feature classes must be used to join sets of phonemes together in an additive way. However, combinations of phonemes from two different places of articulation are attested as phonologically active classes, and the phonetic connections between the post-velar consonants in these classes are often natural. These classes are exactly the type that can be derived using ASSOCIATE constraints, which create feature classes as unions of feature bundles.

### 6.3.3 Tiberian Hebrew: Pharyngeals and Glottals

In Tiberian Hebrew, pharyngeals and glottals pattern together in lowering a following /ə/ in the first syllable of plural forms to [ă], as shown in §3.1.1. The pharyngeals and glottals can be considered a phonologically active natural class in Tiberian Hebrew since articulatory phonetic facts link the two places of articulation. Specifically, the epilaryngeal constriction that must occur with the pharyngeal consonants is facilitated by tongue retraction and larynx raising. Larynx raising often causes ventricular incursion, in which the ventricular folds, which constitute the lower boundary of the epilarynx, come into contact with the glottis. Ventricular incursion is attested with glottal stop ([ʔ]), but not [h] (Moisik 2013:77-79). Thus, an articulatory link between the pharyngeals and /ʔ/ is a likely pathway for phonological interaction to arise. The other glottal phoneme, /h/, is also drawn into this process, likely because /ʔ/ and /h/ share their active articulator.

These phonetic links can be modeled through entailments. These are used in ASSOCIATE constraints to derive the phonologically active natural class of pharyngeals and glottals. First, the constraint ASSOC($\complement_{Phar-Glot}$, [+ce]↔[+cg]) uses an entailment ([+ce]↔[+cg]) that arises from pharyngealized ejectives, such as /q'ˤ/ in Rutul, Tsakhur, and Ubykh, which have both epilaryngeal constriction ([+ce]) and glottal constriction ([+cg]). This constraint calls for adding phonemes bearing [+cg] to a feature class, $\complement_{Phar-Glot}$, which must already contain the feature bundle [+ce]. This links pharyngeals and /ʔ/, but /ʔ/ and /h/ must still be connected, since they do not share [+cg]. The next constraint, ASSOC($\complement_{Phar-Glot}$, [+cg]↔[-front, -raised, -ce]), uses an entailment that arises from the representation of /ʔ/ itself, which is both [+cg] and [-front, -raised, -ce]. The constraint calls for adding phonemes with the feature bundle [-front, -raised, -ce] to $\complement_{Phar-Glot}$. The combined action of these two constraints create the feature class $\complement_{Phar-Glot}$, which has the phonemes /ħ, ʕ, h, ʔ/ as its members. The tableau in (107) shows the derivation of the feature class $\complement_{Phar-Glot}$.

(107) Derivation of Tiberian Hebrew's natural class of pharyngeals and glottals

| | $\mathfrak{C}$ = {[+ce] ∪ [+cg]} | MAX-FF$_{\mathfrak{C}}$ | ASSOC($\mathfrak{C}$, [+ce]↔[+cg]) | ASSOC($\mathfrak{C}$, [+cg]↔[-front, -raised, -ce]) | DEP-FF$_{\mathfrak{C}}$ |
|---|---|---|---|---|---|
| → a. | $\mathfrak{C}$= {[+ce]$_1$ ∪ [+cg]$_{1,2}$ ∪ [-front, -raised, -ce]$_2$} | | | | 3 |
| b. | $\mathfrak{C}$= {[+ce]$_1$ ∪ [+cg]$_{1,2}$ ∪ [-front, -raised, -ce]$_2$ ∪ [+lab]} | 1! | | | 3 |
| c. | $\mathfrak{C}$ = {[+ce]$_1$ ∪ [+cg]$_1$} | | | 1! | 2 |
| d. | $\mathfrak{C}$ = {[+ce]} | 1! | 1 | 2 | |
| e. | $\mathfrak{C}$ = {[+cg]} | 1! | 1 | 1 | |
| f. | $\mathfrak{C}$ = {∅} | | 2! | 2 | |

The first candidate, (a), surfaces as optimal because it contains all and only the feature bundles that are required by the entailments in the ASSOCIATE constraints. Moreover, these feature bundles are all in correspondence, preventing violations of MAX-FF$_{\mathfrak{C}}$. Candidate (b) is the same as candidate (a) except for the fact that it contains the feature [+lab], which is not required by any of the ASSOCIATE constraints. The feature [+lab] is therefore extraneous, and this characteristic is given formal status by its exclusion from any correspondence relationship, which dooms candidate (b) to being eliminated by MAX-FF$_{\mathfrak{C}}$. Candidate (c) shows the consequences of a candidate omitting a feature bundle that is required by an ASSOCIATE constraint. Candidates (d) and (e) also demonstrate this, and show that candidate feature class with only a single feature will always be eliminated because they violate MAX-FF$_{\mathfrak{C}}$. Finally, candidate (f), which contains an empty feature class, is eliminated by the fact that the ASSOCIATE constraints require the presence of both feature bundles. Empty feature classes will always violate any ASSOCIATE constraints to the greatest possible extent. It should also be noted that any ASSOCIATE constraints ranked below DEP-FF$_{\mathfrak{C}}$ will not be able to influence the composition of the feature class since they will always be ruled out in favor of candidate (a), which incurs the minimum number of DEP-FF$_{\mathfrak{C}}$ violations possible while satisfying the higher ranked ASSOCIATE constraints.

## 6.3.4 Coeur d'Alene (Snchitsu'umshtsn): Uvulars and Pharyngeals

In Coeur d'Alene (Interior Salish), the uvulars, pharyngeals, /r/, and /r$^ʔ$/ all function as triggers in the process of regressive faucal retraction harmony, which changes the target vowels /i$_1$, i$_2$, u/, and /a/ to /ɑ, ɛ, ɔ/, and /ɑ/, respectively (see §3.2.4.1 for details). The uvulars, pharyngeals, /r/, and /r$^ʔ$/ can be considered a phonologically active natural class in Coeur d'Alene since they operate in a synchronic process and articulatory phonetic facts can link all of them.

Specifically, tongue retraction is synergistic with (but not obligatory for) epilaryngeal constriction and often co-occurs with it. If the tongue is viewed as a hydrostat in which changes in one region necessarily affect other regions (following Smith and Kier 1989:30), then tongue retraction will also cause the tongue dorsum to retract backward, which is a gesture associated with the feature [+raised]. This is the connection between pharyngeals and uvulars, and for the purposes of deriving feature classes, it can be derived using the constraint ASSOC(ʗ$_{Faucal}$, [+ce]↔[+raised, +open]). This entailment is possible due to the existence of pharyngealized uvular consonants like /qˤ/, which occur in Khwarshi, Tsez, Rutul, Tsakhur, and Ubykh.

The connection between pharyngeals and /r, rˀ/ also relies on tongue retraction. As already noted, tongue retraction is synergistic with pharyngeals, and also appears to be present in Coeur d'Alene /r, rˀ/, which Bessell (1992:98) describes as apical trills "with [the] tongue pulled back." This observation about apical trills (/r/) is also made for Spanish (Delattre 1971) and Catalan (Recasens and Pallarès 1999). Moreover, for Catalan, Recasens and Pallarès (1999:164) write that "[t]he lingual gesture for /r/ is ... antagonistic with respect to that for /i/," which is an effect that is also common with post-velar consonants. The representation of /r/ in Coeur d'Alene, then, is assumed to bear the phonetic subfeature {**tre**} (tongue retraction), which represents the post-velar lingual retraction described in Bessell (1992:98) as "backing." This connection to pharyngeals can be used to derive feature classes through the constraint ASSOC(ʗ$_{Faucal}$, [+ce]↔{**tre**}). The validity of this entailment comes from pharyngeal phonemes in languages in which their primary articulation involves lingual retraction (as in Lebanese Arabic; Delattre 1971:133-134).

The faucal feature class (ʗ$_{Faucal}$) in Coeur d'Alene includes the uvulars, pharyngeals, /r/, and /rˀ/, and can be derived as in (108).

(108) Derivation of Coeur d'Alene's faucal class (ʗ$_{Faucal}$)

| ʗ = {[+ce]} | MAX-FF$_ʗ$ | ASSOC(ʗ, [+ce]↔[+raised, +open]) | ASSOC(ʗ, [+ce]↔{**tre**}) | DEP-FF$_ʗ$ |
|---|---|---|---|---|
| → a. ʗ= {[+ce]$_{1,2}$ ∪ [+raised, +open]$_1$ ∪ {**tre**}$_2$} | | | | 3 |
| b. ʗ= {[+ce]$_{1,2}$ ∪ [+raised, +open]$_1$ ∪ {**tre**}$_2$ ∪ [-front, -raised, -ce]} | 1! | | | 3 |
| c. ʗ = {[+ce]$_1$ ∪ [+raised, +open]$_1$} | | | 1! | 2 |
| d. ʗ = {[+ce]$_1$ ∪ {**tre**}$_1$} | | 1! | | 2 |
| e. ʗ = {[+ce]} | 1! | 1 | 1 | |
| f. ʗ = {∅} | | 2! | 2 | |

Candidate (a) emerges as optimal because it contains all and only the feature bundles that are required by the entailments in the ASSOCIATE constraints in the derivation. Candidate (b) fails because it contains an extraneous feature bundle, [-front, -raised, -ce]. This bundle therefore is not in any correspondence relationship, which violates MAX-FF$_{ʗ}$ and causes candidate (b) to be eliminated. Candidates (c) and (d) each violate one of the ASSOCIATE constraints, but by doing so, they do not violate MAX-FF$_{ʗ}$ since all the feature bundles in the candidates are still in correspondence relationships since they satisfy one of the ASSOCIATE constraints. Candidate (e) shows the fully faithful candidate, which fails because in violating every ASSOCIATE constraint, its single feature bundle, [+ce], never enters into a correspondence relationship and therefore also violates MAX-FF$_{ʗ}$.

### 6.3.5 Filomeno Mata Totonac: Uvulars and Glottals

In Filomeno Mata Totonac (Totonac-Tepehuan), high vowels become mid when they are adjacent to surface uvular consonants and some occurrences of glottal stop, which is the only glottal phoneme in the language (see §3.1.1 for more details). The Totonacan languages are among the very few in which uvulars and glottals pattern together in the absence of pharyngeals (the other is the Samish dialect of Straits Salish; see §6.2.1).

The phonetic connection between uvulars and glottals is less straightforward than the connections between pharyngeals and uvulars or pharyngeals and glottals. Uvular consonants can be aspirated or ejective, which connects uvulars with glottal activity and validates the entailments [+raised, +open]↔[+sg] and [+raised, +open]↔[+cg]. However, because it is surface uvulars, not just uvular phonemes, that are part of the feature class that lowers high vowels in Filomeno Mata Totonac, the entailments cannot be stated purely in terms of phonological features, which are associated with the phoneme itself, not surface allophones. Moreover, for Filomeno Mata Totonac, only /ʔ/ is present, so the entailment [+raised, +open]↔[+sg] can be disregarded. The relevant entailment, however, must be stated in terms of phonetic subfeatures, such that it becomes {**tra**, **vto**}↔{**vfc**}. This general explanation is quite unsatisfying, though, since labial, coronal, and velar stops, which can also be aspirated or ejective, could equally well be said to show the same connection to glottals.

A deeper explanation may be that some of the articulations involved in uvulars and glottals are able to contribute to the articulation of pharyngeal consonants. Tongue retraction inherent in uvulars (especially fricatives) and larynx raising in glottal stop are articulations that are both synergistic with the articulation of pharyngeal consonants (Moisik 2013). This raises the possibility that the reason why uvulars and glottals rarely interact is that their interaction naturally leads to pharyngeal (i.e. epilaryngeal) articulations. In other words, the interaction of uvulars and glottals is rarely observed because it represents an inherently unstable state that is likely either to cease or to lead to a new articulation, namely epilaryngeal constriction in pharyngeal consonants.

The derivation of the feature class in Filomeno Mata Totonac that includes uvulars and glottal stop proceeds straightforwardly using the entailment outlined above, and is shown in (109).

(109) Derivation of a feature class ($ʗ_{Uv-Gl}$) containing uvulars and glottal stop in Filomeno Mata Totonac

| ʗ = {{**tra**, **vto**}} | MAX-FF$_ʗ$ | ASSOC(ʗ, {**tra**, **vto**}↔{**vfc**}) | DEP-FF$_ʗ$ |
|---|---|---|---|
| → a. ʗ= {{**tra**, **vto**}$_1$ ∪ {**vfc**}$_1$} | | | 2 |
| b. ʗ= {{**tra**, **vto**} ∪ [-front, -raised, -ce]} | 2! | 1 | |
| c. ʗ = {{**tra**, **vto**}} | 1! | 1 | |
| d. ʗ = {∅} | | 2! | |

Candidate (a) surfaces as optimal because it contains all and only the feature bundles that are required by the entailments in the ASSOCIATE constraints. Candidate (b) represents a feature class that unites uvulars and glottals generally, but not according to any ASSOCIATE constraints in the derivation. This means that the feature bundles in (b) are not in a correspondence relationship, and thus violate MAX-FF$_ʗ$.[9] Although candidate (c) is fully faithful to the input feature class, its feature bundle is not in a correspondence relationship, and therefore it violates MAX-FF$_ʗ$. Both candidate (b) and candidate (c) violate ASSOC(ʗ, {**tra**, **vto**}↔{**vfc**}) since they contain the bundle {**tra**, **vto**}, but not {**vfc**}.

### 6.3.6 Arabic: Uvular Fricatives, Pharyngeals, and Glottals

In Arabic, a variety of processes provide evidence for a phonologically active class, termed the guttural natural class, that includes the uvular fricatives (notably not the stop /q/), pharyngeals, and glottals (for examples, see §3 and discussion in McCarthy 1994). McCarthy (1994) argues that the gutturals are not only a phonologically active class, but a phonetically natural class. By the definition of naturalness in this study, the gutturals (in Arabic) are a phonetically natural class, but instead of claiming that a single phonetic characteristic unifies all the sounds in it, the approach I propose in this study derives the class using the phonetic connections between individual groups of those sounds.

As noted in §5.4.2.1, Arabic's differential treatment of /q/ and the uvular fricatives is not cross-linguistically typical, and the task is to formally account for it in a language-specific way. A possible explanation for the differential patterning of the uvular stop and fricatives is a difference in their articulation. Moisik (2013:463-467) argues that uvular stops, such as /q/, may have only very weak tongue retraction ({**tre**}), whereas tongue retraction may be more important for uvular fricatives (/χ, ʁ/). To model this formally, the gross state for tongue retraction, {**tre**}, is associated in this study with the principal allophones of the uvular fricatives in Arabic ([χ, ʁ]), but not with allophones of /q/. Associating {**tre**} only with allophones of /χ/ and /ʁ/, not with their phonological representation, allows the phonetic explanation for the differential patterning of /q/ and /χ, ʁ/ in

[9] If there were a constraint ASSOC(ʗ, {**tra, vto**}↔[-front, -raised, -ce]) that did unify the uvulars and glottals generally, then it could still be ranked below DEP-FF$_ʗ$ such that satisfying the constraint would be more costly than violating it. Even though the candidate would then not violate MAX-FF$_ʗ$, it would be eliminated for violating DEP-FF$_ʗ$ more than a form like candidate (a).

Arabic to be used in formal phonological derivations while avoiding the undesirable prediction that uvular stops and fricatives should behave differently from each other in the phonology of every language.

The phonetic connection between the uvular fricatives and pharyngeals of Arabic has the same explanation as that which was outlined for Coeur d'Alene in §6.3.4, but the ASSOCIATE constraint for Arabic will be different since uvular fricatives need to be referenced apart from uvulars as a whole. Under the view of the tongue as a hydrostat, the tongue retraction that is synergistic with the epilaryngeal constriction that is obligatory for pharyngeals will necessarily affect the lingual articulation of uvular consonants, especially that of uvular fricatives. Based on the idea that tongue retraction is more important in uvular fricatives (Moisik 2013:463-467) and on evidence that pharyngeal consonants in Arabic involve tongue retraction (Delattre 1971:133-134), the constraint that connects pharyngeals and uvular fricatives in the guttural feature class (ʗ$_{Guttural}$) in Arabic is ASSOC(ʗ$_{Guttural}$, [+ce]↔{**tre**}).

The phonetic connection between pharyngeals and glottals is the same as that outlined for another Semitic language, Tiberian Hebrew, in §6.3.3. Larynx raising ({**rlx**}) is synergistic with the epilaryngeal constriction ({**epc**}) that must occur in pharyngeal consonants (which are [+ce]). Larynx raising occurs in glottal stop (/ʔ/; [+cg]), which means that the constraint ASSOC(ʗ$_{Guttural}$, [+ce]↔[+cg]) will add glottal stop to the guttural feature class. Another constraint, though, is needed to add /h/, which does not typically exhibit larynx raising. This constraint is ASSOC(ʗ$_{Guttural}$, [+cg]↔[-front, -raised, -ce]), familiar from the derivation of the uvular and glottal feature class in Tiberian Hebrew (§6.3.3).

Deriving the guttural feature class thus relies on the action of three ASSOCIATE constraints which are based on the phonetic connections between pharyngeals and uvular fricatives, pharyngeals and glottal stop, and glottal stop with glottals as a whole. This derivation is shown in (110).

(110) Derivation of the guttural feature class (ʗ$_{Guttural}$) in Arabic, which includes uvular fricatives, pharyngeals, and glottals

| ʗ = {[+ce] ∪ [+cg]} | MAX-FFʗ | ASSOC(ʗ, [+ce]↔{**tre**}) | ASSOC(ʗ, [+ce]↔[+cg]) | ASSOC(ʗ, [+cg]↔[-front, -raised, -ce]) | DEP-FFʗ |
|---|---|---|---|---|---|
| → a. ʗ= {[+ce]$_{1,2}$ ∪ {**tre**}$_1$ ∪ [+cg]$_{2,3}$ ∪ [-front, -raised, -ce]$_3$} | | | | | 4 |
| b. ʗ= {[+ce]$_{1,2}$ ∪ {**tre**}$_1$ ∪ [+cg]$_2$} | | | | 1! | 3 |
| c. ʗ = {[+ce]$_1$ ∪ {**tre**}$_1$} | | | 1! | 2 | 2 |
| d. ʗ = {[+ce]$_1$ ∪ [+cg]$_{1,2}$ ∪ [-front, -raised, -ce]$_2$} | | 1! | | | 3 |
| e. ʗ = {[+ce] ∪ [-front, -raised, -ce]} | 2! | 1 | 1 | 1 | |
| f. ʗ = {∅} | | 2! | 2 | 2 | |

Candidate (a) surfaces as optimal because it contains all and only the feature bundles that are required by the entailments in the active ASSOCIATE constraints in the derivation. This satisfies those constraints and ensures that all the feature bundles in (a) are in correspondence, which in turn satisfies MAX-FF$_{ʗ}$. In candidate (b), all the feature bundles present are in correspondence, but the feature bundle [-front, -raised, -ce] is absent, even though it is required by ASSOC(ʗ, [+cg]↔[-front, -raised, -ce]). This leads to a violation of that constraint, and the elimination of candidate (b). Candidates (c) and (d) fail for similar reasons, and violate the other ASSOCIATE constraints. Candidate (e) includes feature bundles that specify pharyngeal and glottal phonemes, but none of the ASSOCIATE constraints force [+ce] (which specifies pharyngeals) to directly entail [-front, -raised, -ce] (which specifies glottals), even though both feature bundles occur in the optimal feature class in candidate (a). Thus, these two feature bundles are not in a correspondence relationship and each violate MAX-FF$_{ʗ}$. In addition, [+cg] is required by the entailments of two ASSOCIATE constraints, and its absence leads to violations, as does the absence of {**tre**}.

## 6.4 Naturalness and Complexity of Post-Velar Natural Classes

The derivation of feature classes that I have proposed here differentiates natural from unnatural classes and provides at least two ways of assessing the formal complexity of natural classes. One way, which is reminiscent of the feature-counting naturalness metric of Chomsky and Halle (1968:400), is to measure the naturalness of a given feature class by the number of ASSOCIATE constraints that are required to derive it.[10] If natural classes are derived as argued here, by using phonological entailments to unify feature bundles that describe sets of phonemes, then the number of ASSOCIATE constraints can be viewed as the number of phonetic links that a language must use to relate the phonemes that pattern together as a natural class. Table 6.4 shows the number of ASSOCIATE constraints that were needed to derive the post-velar natural classes in each language.

| *Language* | *Natural Class* | *Number of* ASSOCIATE *Constraints* |
|---|---|---|
| Aymara | Uvulars | 0 |
| Avar | Pharyngeals | 0 |
| Kashaya | Glottals | 0 |
| Tiberian Hebrew | Pharyngeals and Glottals | 2 |
| Coeur d'Alene | Faucals (uv, phar, /r/, /r$^{ʔ}$/) | 2 |
| Filomeno Mata Totonac | Uvulars and Glottals | 1 |
| Arabic | Gutturals (uv fric, phar, glot) | 3 |

Table 6.4: Number of entailments needed to derive some post-velar natural classes

[10]This is equivalent to saying that the naturalness of a natural class can be measured by the number of entailments that are needed to derive it because natural classes are derived as feature classes and each ASSOCIATE constraint uses two entailments.

The simplest classes are those which can be referred to using a single bundle of features. No entailments are needed to derive these classes. Because feature classes are defined by the union of two feature bundles by an entailment, every natural class that is derived as a feature class must use at least one ASSOCIATE constraint.

For Tiberian Hebrew, one ASSOCIATE constraint unifies pharyngeals and /ʔ/ while the other unifies /ʔ/ and all other glottals. Although the articulatory connection between pharyngeals and the glottis is easily explainable and can be modeled with a single entailment, the glottals cannot be identified uniquely under the current representational scheme. This should not be seen as a representational insufficiency since the articulations of glottal stops and glottal fricatives are quite different physiologically, with glottal stop, but not /h/, often involving ventricular incursion (Moisik 2013:77-79). The ASSOCIATE constraints capture this detail by targeting only /ʔ/ rather than targeting all glottals.

Similarly, in Coeur d'Alene, the connection between uvulars and pharyngeals is straightforward and is modeled with a single entailment. However, the need to encompass /r/ and /rˀ/ in addition means that another entailment must be used. This derivation makes the prediction that the connection uniting uvulars and pharyngeals is different from that uniting pharyngeals and /r, rˀ/. The expectation, then, is that at an earlier stage of the language, one of these connections was not originally present, but was added at a later stage in a gradual expansion of the class. This addition increased the complexity of the natural class.

The case of Filomeno Mata Totonac is potentially problematic. The phonetic connection between uvulars and glottals is neither obvious nor strong, and a version of the single entailment that derives it could be used to derive a connection between glottals and any other more anterior place of articulation. Thus, Filomeno Mata Totonac's uvular-glottal feature class can be derived with just one ASSOCIATE constraint, but from a phonetic point of view, it may be less natural than a feature class that unites uvulars and pharyngeals. A more nuanced naturalness metric should be able to account for the difference between these two feature classes.

Arabic's guttural natural class is the most complex of those derived in this section. This is because multiple phonetic connections are needed to link the groups of phonemes that compose the guttural natural class. A separate phonetic connection motivates the linking of uvular fricatives and pharyngeals, of pharyngeals and glottal stop, and of glottal stop with the glottals as a whole (which in this case adds only /h/). While the phonetic naturalness of the guttural natural class was recognized by Hayward and Hayward (1989) and McCarthy (1991, 1994), a unifying acoustic or articulatory phonetic characteristic has not been found. The reason for this is not that the guttural natural class is actually unnatural, but that different subsets of its constituent phonemes are unified by different phonetic characteristics which are each more transparently natural than the overall grouping.

Another possible naturalness metric could come from weighting the ASSOCIATE constraints according to cross-linguistic data. For example, if the set of possible entailments is derived (following the suggestion in §5.5), then these entailments could be put into ASSOCIATE constraints and the degree to which each of these are necessary for accounting for natural classes could be assessed. For example, it would be possible to use logistic regression to determine the extent to which each ASSOCIATE constraint accounts for each natural class from a large sample, such as that supplied here or in Mielke's *P-base* (2008). The naturalness of a particular natural class might then be the sum of the weights of the ASSOCIATE constraints that are needed to derive it. Because this would incorporate information on the cross-linguistic commonality of particular phonetic connections within natural classes, it may be able to more insightfully model the difference between Filomeno Mata Totonac's natural class of uvulars and glottal stop and, for example, Tiberian Hebrew's natural class of pharyngeals and glottals.

## 6.5 Summary and Conclusions

This chapter focused first on evaluating the claim that a guttural natural class, composed of uvulars, pharyngeals, and glottals, is an innate part of human language. By querying *P-base*, I showed that not all combinations of post-velar places of articulation are equally attested as phonologically active classes, contra the expectations that arise from positing an innate guttural natural class. This shows the benefits of querying large databases to examine hypotheses about the nature of linguistic structure. Future research would benefit from a detailed assessment of each natural class that has been proposed to be universal, starting with others that are proposed to be based on place of articulation.

It was proposed that the skewed distribution of evidence for a phonologically active post-velar class could be better explained by deriving phonological classes based on phonetic connections among the post-velar consonants. This derivational system easily handles variation, both cross-linguistic and within a language. The feature classes that are derived are necessarily language-specific, which means that cross-linguistic variation is not a problem. Similarly, phonemes can belong to more than one feature class, which renders ambivalent segments unproblematic. In any case of variation, what is important is that the variation can be explained, either as phonetically natural or unnatural. In either case, the derivational framework proposed here can model the resulting class.

This chapter also showed that phonologically active classes of post-velar consonants in Tiberian Hebrew, Coeur d'Alene, and Filomeno Mata Totonac can be derived as feature classes using the derivational system proposed in chapter 5. Importantly, it was shown that this framework can derive the guttural natural class in Arabic, providing a theoretical alternative to positing the guttural natural class as an innate representational entity. Deriving these frameworks illustrated the utility of the representations from chapter 4. Language-specific patterns, namely the retraction of rhotic phonemes in Coeur d'Alene and the split between uvular stops and fricatives in Arabic, were explained by referencing phonetic subfeatures (namely {**tre**}) that were associated with the specific realizations (as allophones) of those phonemes in those languages. It was also necessary to reference the uvular articulation of allophones of the phonemes /q, x, n/ in Filomeno Mata Totonac.

Finally, it was shown that the new theoretical framework for deriving natural classes that is proposed here offers two possible naturalness metrics. One metric is simply counting the number of ASSOCIATE constraints that are necessary to derive each natural class. The other metric sums the weights of ASSOCIATE constraints, which could be assigned by using logistic regression to model the extent to which each ASSOCIATE constraint accounts for cross-linguistically attested natural classes from a database.

# Chapter 7

# Conclusion

## 7.1 Summary

This dissertation proposed a new theoretical framework for deriving natural classes, which was supported by evidence from a survey of the sound patterns and phonemic inventories of 291 languages with post-velar consonants.

Chapter 2 presented the phonemic inventories of all the languages surveyed. This revealed which post-velar consonants are attested in the world's languages and which phonemic contrasts exist between them. In addition, the survey revealed the areal patterning of languages with (non-glottal) post-velar consonants, and the results suggest a possible correlation with residual zones, although this must be statistically tested.

Chapter 3 presented the results of surveying the sound patterns in the surveyed languages that involve the post-velar consonants. It was shown that the post-velar consonants, particularly the uvulars and pharyngeals, commonly cause changes to the quality of adjacent vowels. Glottals affect vowels only rarely, and usually do so only in combination with other post-velar consonants. The most common effect of the post-velar consonants is lowering. Backing is less common than previously thought, and pharyngeals cause fronting effects in Egyptian Arabic, Kabardian, and several Northeast Caucasian languages.

Post-velar harmony processes occur in unrelated languages in diverse geographic regions. Languages like Arabic, the Interior Salish languages, Azerbaijani Jewish Aramaic, and Tashlhiyt Berber show CV harmony in which a post-velar secondary articulation spreads through both consonants and vowels. This is regulated by phonological and morphological factors in Arabic and Interior Salish, by speech rate in Tashlhiyt Berber, and is often prevalent throughout the whole word in Azerbaijani Jewish Aramaic. In Tsilhqot'in, pharyngealization spreads from a consonant to a vowel in processes with various locality restrictions, and these spreading processes co-exist with a system of consonant harmony that causes pharyngealization agreement between non-lateral coronal affricates and fricatives. In addition, the patterns of transparency and opacity in Arabic, Interior Salish, and Tsilhqot'in show that while /i/ tends to block harmony to the right (acting as opaque), harmony on the left is often unbounded and /i/ acts as transparent. This indicates a possible right-to-left (anticipatory, regressive) bias in post-velar harmony processes, which would establish a point of similarity between them and consonant harmony processes. In the northeast Caucasus, Rutul shows simultaneous consonant harmony, with uvulars agreeing in pharyngealization, and consonant-vowel harmony, with vowels being pharyngealized adjacent to pharyngealized consonants. Under an Agreement-by-Correspondence analysis, this system points to the need to have multiple correspondence relations within a single form. The pharyngealization harmony system of Icari Dargwa is heavily restricted by morphology, to the point that the system is perhaps better viewed as a system of morphological agreement than phonological harmony.

It was also shown in chapter 3 that processes that have been called guttural transparency may not exist as previously conceived. Guttural transparency as a process in which vowels must be identical across all post-velar consonants does not occur in any language. Patterns in which vowels must be identical across laryngeal and pharyngeal consonants, which I termed non-lingual transparency, are well-attested, but no system requires all vowels to be identical across uvular consonants. The systems that came closest to true guttural transparency had non-lingual transparency in addition to requirements for certain vowels to be identical across uvular consonants. These latter requirements occurred in Iraqw (Cushitic) and Eastern Gitksan (Tsimshianic), and I termed them dorsal transparency. They always involved vowels whose articulations are most similar to those of uvulars, namely high round /u/, and also /o/ and /a/ in Eastern Gitksan. Thus, what has been termed guttural transparency can be separated into non-lingual transparency and dorsal transparency.

The results of the survey of phonemic inventories form the basis of the findings in chapter 4, which presents a new conception of phonological representation and specifically a new proposal for how the post-velar consonants should be represented. I proposed that because natural classes can be derived, phonological representation should be responsible only for capturing phonemic contrast and phonetic details that are phonologically relevant, but non-contrastive. From this point of view, traditional phonological features are associated with phonemes themselves which are argued to have a cross-linguistically universal representation based on phonemic contrast. Phonetic subfeatures are associated with the language-specific allophones of those phonemes, and these capture articulatory and acoustic characteristics that are necessary to describe sound patterns that rely on phonetically relevant, but non-contrastive, properties of allophones in a language. Vowel lowering in Filomeno Mata Totonac was shown to depend on the identification of a segment as uvular, even when a sound did not have an underlying velar-uvular contrast (e.g. /x/, which does not contrast underlyingly with */χ/).

Apart from this conceptual shift, I argued for a new phonological feature representation of the post-velar consonants that captures all the attested phonemic contrasts within the languages surveyed. This featural representation does away with the features [±high, ±back, ±low] as consonantal features[1] in favor of the features [±fronted, ±raised, ±retracted], which more accurately describe the possible motions of the tongue (Esling 2005; Moisik 2013). In addition, the new featural representation uses the feature [±constricted epilarynx] ([±ce]) to represent pharyngeal articulations on either consonants or vowels. Epilaryngeal constriction is obligatory for pharyn-

[1]These are still retained for the time being for vowels since reevaluating their representations lies outside the scope of this study.

geal consonants, and using a separate feature, [±ce], prevents this articulation from being conflated with lingual articulations, especially tongue body retraction. Tongue body retraction is synergistic with epilaryngeal constriction and commonly accompanies it, but is not obligatory.

In chapter 5, I proposed a new theoretical model for deriving phonological classes that differentiates unnatural classes from natural classes by grounding naturalness in the co-occurrence of phonological features and phonetic subfeatures. This co-occurrence provides the basis for phonological entailments, which are incorporated into ASSOCIATE constraints. These constraints, which are used to derive natural classes as feature classes (Padgett 1995, 2002), call for the presence of the two feature bundles required by the symmetrical entailments that they contain. The ASSOCIATE constraints also establish a surface correspondence relationship between the two feature bundles they require, and regulating those correspondence relationships determines which feature bundles are in the feature class. One constraint, MAX-FF$_{\mathbb{C}}$, penalizes feature bundles that are not in correspondence, and eliminates feature bundles that are not required by any ASSOCIATE constraints. Another constraint, DEP-FF$_{\mathbb{C}}$, penalizes feature bundles that are in correspondence, and countervails the effects of the ASSOCIATE constraints. The feature bundles that are required by the ASSOCIATE constraints that are ranked above DEP-FF$_{\mathbb{C}}$ are included in the feature class while those that are required by ASSOCIATE constraints that are ranked below DEP-FF$_{\mathbb{C}}$ are excluded. This system of deriving natural classes provides testable predictions that can be used to evaluate it and to shed light on which phonetic connections between phonemes are most commonly used to form natural classes and by extension may be important for human speech as a whole.

Finally, chapter 6 showed that this system can be used to derive natural classes that contain various combinations of post-velar consonants. After justifying the need for this system by showing that the presence of a phonological class of post-velar consonants is partially contingent on the presence of a pharyngeal consonant, the chapter turned to deriving specific natural classes composed of post-velar consonants that were discovered through the typological survey. These included a class composed of pharyngeals and glottals in Tiberian Hebrew, the faucal class (uvulars, pharyngeals, /r/, and /ˀr/) in Coeur d'Alene, the uvulars and glottal stop in Filomeno Mata Totonac, and the guttural natural class in Arabic. Using the results of deriving these example natural classes, I discussed two naturalness metrics that were made possible by the proposed derivational system. One naturalness metric involved counting the number of ASSOCIATE constraints used to derive a natural class. I also discussed the possibility of implementing a more nuanced naturalness metric that relies on finding a cross-linguistic weighting of all the possible ASSOCIATE constraints.

## 7.2 Future Directions

Further research is needed both to fully understand the post-velar consonants and to derive further insight from the theoretical framework proposed here.

Although the articulation of the pharyngeal and glottal consonants is now quite well-understood, further research should investigate the articulations of uvular consonants across a wider variety of languages to provide a typology that meaningfully distinguishes their realizations and establishes diagnostics that field researchers and phoneticians can use to increase the likelihood that their descriptions are phonetically accurate. Although the uvular consonants have frequently been recognized as "ambivalent" phonemes that can pattern either with dorsals or with post-velars (McCarthy 1994; Rose 1996; Yamane-Tanaka 2006, among others), extensive phonetic research has not yet evaluated the extent to which their phonological patterning may correlate with their phonetic realization.

Outside of articulation, perceptual research on post-velar consonants is sorely needed. While a number of studies (including Alwan 1986, Shahin 2002, and Zawaydeh 1999, 2003, among others) provide important results that show the salience of acoustic characteristics for perceiving post-velars in Arabic, the perceptibility and confusability of post-velars should be assessed for a larger number of languages.[2] This perceptual research on post-velar consonants is essential for fully understanding how they are affected in sound change, especially processes such as hyper- and hypocorrection (Ohala 1981). This, combined with a systematic survey of how post-velars are affected in sound change, could offer ways to resolve the debate surrounding the identity of Proto-Indo-European's "laryngeal" segments (Kuryłowicz 1927; Garrett 1991).

A fruitful area for phonological research is the extent to which the phonetics and phonology of advanced/retracted tongue root harmony can be seen as post-velar harmony. The Nilotic language Datooga (§2.4.1) developed a contrast between velar /k/ and uvular /q/ as a result of the contextual effects of ATR harmony. This indicates that while ATR harmony is traditionally seen as a vowel harmony process, it has the potential to have effects on consonants and can lead to the genesis of post-velar consonants. ATR harmony is common throughout Sub-Saharan Africa north of the Kalahari Basin, and there are indications that apart from ATR harmony, other post-velar phenomena may be waiting to be discovered in that area. For example, Minyanka, a Senufo language, has a pharyngeal consonant, and Wolof contrasts velar /k/ and uvular /q/. Studying both ATR harmony processes and doing a more detailed survey of post-velars in Sub-Saharan Africa could yield phonological insights and expand the typology of post-velar consonants.

The theoretical system that I proposed in this dissertation should also be extended to derive natural classes other than those that involve post-velar consonants. One promising direction is to derive natural classes that involve palatalization, which is often recalcitrant to a purely feature-based analysis.

In addition, the theoretical system I proposed in this dissertation makes several predictions about natural classes that can be tested computationally and experimentally, as suggested in §5.5. Testing these predictions can be done by computationally evaluating the ability of the system to account for natural classes on a large scale. To do this, the full set of entailments would need to be derived, and this would involve assigning contrast-motivated phonological representations to all cross-linguistically attested phonemes. The full set of entailments could then be incorporated into ASSOCIATE constraints, and these would be used to account for a large number of phonological classes. The ASSOCIATE constraints that are necessary to account for the largest numbers of phonological classes will reveal the entailments, and therefore phonetic connections, which may

[2]Aside from more general issues of perceptibility and confusability, the pitch (F0) changes that post-velar consonants cause are not fully understood, and an investigation of these effects has the potential to lead to insights on tonogenesis.

be most important in language.

After this kind of evaluation of the theoretical model proposed here, experiments could be used to assess the extent to which common entailments may influence speakers' learning of sound patterns. Artificial grammar learning experiments are one method that could be used to discover this bias, and further experimentation, along the lines of Wilson (2006), Moreton (2008), and Yu (2011), could be done to determine whether this bias is substantive or analytic.

# Bibliography

ABDEL-MASSIH, ERNEST T. 1971. *A Reference Grammar of Tamazight: A Comparative Study of the Berber Dialects of Ayt Ayache and Ayt Seghrouchen*. Ann Arbor, MI: University of Michigan Center for Near Eastern and North African Studies.

ABDULLAEV, Z. G. 1967. Darginskij jazyk. *Iberijsko-kavkazskie jazyki*, *Jazyki narodov SSSR*, vol. 4, edited by E. A. Bokarev and K. V. Lomtatidze, Moscow: Akademija Nauk SSSR, 276–292.

ADELAAR, ALEXANDER. 1997. Grammar notes on Siraya, an extinct Formosan language. *Oceanic Linguistics* 36(2):362–397.

ADELAAR, WILLEM F. H. and PIETER C. MUYSKEN. 2004. *The Languages of the Andes*. Cambridge, UK: Cambridge University Press.

AGUILERA, OSCAR E. 2001. *Gramática de la Lengua Kawésqar*. Temuco, Chile: Corporación Nacional de Desarrollo Indígena.

ALEKSEEV, MIKHAIL and C. X. ŠIXALIEVA. 2003. *Tabasaranskij jazyk*. Moscow: Academia.

ALEKSEEV, MIKHAIL E. 1994a. Budukh. *The Northeast Caucasian Languages, Part 2*, *The Indigenous Languages of the Caucasus*, vol. 4, edited by Rieks Smeets, Delmar, NY: Caravan Books, 259–296.

ALEKSEEV, MIKHAIL E. 1994b. Rutul. *The Northeast Caucasian Languages, Part 2*, *The Indigenous Languages of the Caucasus*, vol. 4, edited by Rieks Smeets, Delmar, NY: Caravan Books, 213–258.

ALWAN, ABEER ABDUL-HUSSAIN. 1986. *Acoustic and Perceptual Correlates of Pharyngeal and Uvular Consonants*. Master's thesis, Massachusetts Institute of Technology, Cambridge, MA.

ANDERSON, GREGORY. 1997. Lak phonology. *Phonologies of Asia and Africa (including the Caucasus)*, edited by Alan S. Kaye and Peter T. Daniels, Winona Lake, IN: Eisenbrauns, 973–997.

ANDRADE, MANUEL JOSÉ. 1933. *Quileute*. New York: Columbia University Press.

AOKI, HARUO. 1965. *Nez Perce Grammar*. Ph.D. thesis, University of California, Berkeley, Berkeley, CA.

ARALOVA, NATALIA; SVEN GRAWUNDER; and BODO WINTER. 2011. The acoustic correlates of tongue root vowel harmony in Even (Tungusic). *ICPhS XVII*, Hong Kong, 240–243.

ARCHANGELI, DIANA and DOUGLAS PULLEYBLANK. 1994. *Grounded Phonology*. Cambridge, MA: MIT Press. Not read. Cited in Shahin (2002).

ARTEM'EV, NIKOLAJ MATVEEVIČ. 2001. *Dolganskij jazyk: Dolgan-haka tyla (Čast' 1)*. St. Petersburg: Izdatel'stvo RPGU im. A. I. Gercena.

AUTHIER, GILLES. 2009. *Grammaire Kryz (langue caucasique d'Azerbaïdjan, dialecte d'Alik)*. Paris: Peeters.

AVERY, PETER and KEREN RICE. 1989. Segment structure and coronal underspecification. *Phonology* 6:179–200.

AVRORIN, V. A. 1959. *Grammatika nanajskogo jazyka*. Moscow: Akademija Nauk SSSR.

AVRORIN, V. A. and B. V. BOLDYREV. 2001. *Grammatika oročskogo jazyka*. Novosibirsk: Izdatel'stvo SO RAN.

BABUŠKIN, G. F. and G. I. DONIDZE. 1966. Šorskij jazyk. *Tjurkskie jazyki*, *Jazyki narodov SSSR*, vol. 2, edited by N. A. Baskakov, Moscow: Akademija Nauk SSSR, 467–481.

BAGEMIHL, BRUCE. 1991. Syllable structure in Bella Coola. *Linguistic Inquiry* 22:589–646.

BAKAEV, ČERKES XUDOEVIČ. 1973. *Jazyk kurdov SSSR*. Moscow: Nauka.

BASHIR, ELENA. 2009. Wakhi. *The Iranian Languages*, edited by Gernot Windfuhr, New York: Routledge, 825–862.

BASKAKOV, N. A. 1966a. Altajskij jazyk. *Tjurkskie jazyki*, *Jazyki narodov SSSR*, vol. 2, edited by N. A. Baskakov, Moscow: Akademija Nauk SSSR, 506–522.

BASKAKOV, N. A. 1966b. Nogajskij jazyk. *Tjurkskie jazyki*, *Jazyki narodov SSSR*, vol. 2, edited by N. A. Baskakov, Moscow: Akademija Nauk SSSR, 280–300.

BECK, DAVID. 1996. Some notes on phonological phrasing in Lushootseed. *Toronto Working Papers in Linguistics* 15:37–60.

BELL, ARTHUR J. 2003. Gemination, degemination, and moraic structure in Wolof. *Working Papers of the Cornell Phonetics Lab* 15:1–68.

BERMAN, RUTH A. 1997. Modern Hebrew. *The Semitic Languages*, edited by Robert Hetzron, London: Routledge, 312–333.

BESSELL, NICOLA J. 1992. *Towards a Phonetic and Phonological Typology of Post-Velar Articulation*. Ph.D. thesis, University of British Columbia, Vancouver, BC.

BESSELL, NICOLA J. 1998a. Local and non-local consonant-vowel interaction in Interior Salish. *Phonology* 15:1–40.

BESSELL, NICOLA J. 1998b. Phonetic aspects of retraction in Interior Salish. *Salish Languages and Linguistics: Theoretical and Descriptive Perspectives*, *Trends in Linguistics*, vol. 107, edited by Ewa Czaykowska-Higgins and M. Dale Kinkade, Berlin: Mouton de Gruyter, *Trends in Linguistics*, vol. 107, 125–152.

BICKEL, BALTHASAR and JOHANNA NICHOLS. 2006. Oceania, the Pacific Rim, and the theory of linguistic areas. *Proceedings of the 32nd Annual Meeting of the Berkeley Linguistics Society*, Berkeley, CA: Berkeley Linguistics Society.

BIN-MUQBIL, MUSAED S. 2006. *Phonetic and Phonological Aspects of Arabic Emphatics and Gutturals*. Ph.D. thesis, University of Wisconsin-Madison, Madison, WI.

BLACK, PAUL. 1976. Werizoid. *The Non-Semitic Languages of Ethiopia*, *Occasional Papers Series, Committee on Ethiopian Studies*, vol. 5, edited by M. Lionel Bender, East Lansing, MI: African Studies Center of Michigan State University, 222–231.

BLANC, H. 1970. The Arabic dialect of the Negev Bedouins. *Proceedings of the Israel Academy of Sciences and Humanities* 4:112–150.

BLANC, HAIM. 1953. *Studies in North Palestinian Arabic: Linguistic Inquiries Among the Druzes of Western Galilee and Mt. Carmel*. Oriental Notes and Studies, Jerusalem: The Israel Oriental Society.

BLUST, ROBERT. 1999a. Notes on Pazeh phonology and morphology. *Oceanic Linguistics* 38(2):321–365.

BLUST, ROBERT. 1999b. Subgrouping, circularity and extinction: Some issues in Austronesian and comparative linguistics. *Selected Papers From the Eighth International Conference on Austronesian Linguistics*, edited by Elizabeth Zeitoun and Paul Jen kuei Li, Taipei: Academia Sinica, 31–94.

BLUST, ROBERT. 2003. *Thao Dictionary*. Language and Linguistics Monograph Series A5, Taipei: Academia Sinica.

BOBALJIK, JONATHAN. 1996. Assimilation in the Inuit languages and the place of the uvular nasal. *International Journal of American Linguistics* 62(4):323–350.

BOBALJIK, JONATHAN. 2006. Itelmen reduplication: Edge-in association and lexical stratification. *Journal of Linguistics* 42(1):1–23.

BOKAREV, E. A. and G. I. MADIEVA. 1967. Bežtinskij jazyk. *Iberijsko-kavkazskie jazyki*, *Jazyki narodov SSSR*, vol. 4, edited by E. A. Bokarev and K. V. Lomtatidze, Moscow: Akademija Nauk SSSR, 455–471.

BORG, ALBERT and MARIE AZZOPARDI-ALEXANDER. 1997. *Maltese*. London: Routledge.

BORGES, MÔNICA VELOSO. 2006. *Aspectos fonológicos e morfossintáticos da língua avá-canoeiro (tupí-guaraní)*. Doctoral thesis, Universidade Estadual de Campinas.

BOUDA, KARL. 1949. *Lakkische Studien*. Heidelberg: Winter.

BOUKOUS, AHMED. 2009. *Phonologie de l'amazighe*. Rabat, Morocco: Institut Royal de la Culture Amazighe.

BOWERN, CLAIRE. 2011. How many languages were spoken in Australia? Http://anggarrgoon.wordpress.com/2011/12/23/how-many-languages-were-spoken-in-australia/.

BRIGHT, JANE O. 1964. The phonology of Smith River Athapaskan (Tolowa). *International Journal of American Linguistics* 30(2):101–107.

BROWMAN, CATHERINE P. and LOUIS GOLDSTEIN. 1986. Towards an articulatory phonology. *Phonology Yearbook* 3:219–252.

BUCKLEY, EUGENE L. 1994. *Theoretical Aspects of Kashaya Phonology and Morphology*. Dissertations in Linguistics, Stanford, CA: CSLI.

BURZIO, LUIGI. 2002a. Missing players: Phonology and the past-tense debate. *Lingua* 112:157–199.

BURZIO, LUIGI. 2002b. Surface-to-surface morphology: When your representations turn into constraints. *Many Morphologies*, edited by Paul Boucher, Somerville, MA: Cascadilla Press, 142–177.

CAMPBELL, LYLE. 1997. *American Indian Languages: The Historical Linguistics of Native America*. Oxford, UK: Oxford University Press.

CAMPBELL, LYLE and VERÓNICA GRONDONA. 2012. Languages of the Chaco and Southern Cone. *The Indigenous Languages of South America: A Comprehensive Guide*, edited by Lyle Campbell and Verónica Grondona, Berlin: Mouton de Gruyter, 625–668.

CAMPBELL, LYLE and TERRENCE KAUFMAN. 1985. Mayan linguistics: Where are we now? *Annual Review of Anthropology* 14:187–198.

CARLSON, BARRY F. and JOHN H. ESLING. 2003. Phonetics and physiology of the historical shift of uvulars to pharyngeals in Nuuchahnulth (Nootka). *Journal of the International Phonetic Association* 33(2):183–193.

CARLSON, BARRY F.; JOHN H. ESLING; and KATIE FRASER. 2001. Nuuchahnulth. *Journal of the International Phonetic Association* 31(2):275–279.

CARLSON, BARRY F.; JOHN H. ESLING; and JIMMY G. HARRIS. 2004. A laryngoscopic phonetic study of Nlaka'pamux (Thompson) Salish glottal stop, glottalized resonants, and pharyngeals. *Studies in Salish Linguistics in Honor of M. Dale Kinkade*, *University of Montana Occasional Papers in Linguistics*, vol. 17, edited by Donna Gerdts and Lisa Matthewson, Missoula, MT: University of Montana, *University of Montana Occasional Papers in Linguistics*, vol. 17, 58–71.

CARLSON, ROBERT. 1994. *A Grammar of Supyire*. Berlin: Mouton de Gruyter.

CATFORD, JOHN C. 1977a. *Fundamental Problems in Phonetics*. Bloomington, IN: Indiana University Press.

CATFORD, JOHN C. 1977b. Mountain of tongues: The languages of the Caucasus. *Annual Review of Anthropology* 6:283–314.

CATFORD, JOHN CUNNISON. 1983. Pharyngeal and laryngeal sounds in Caucasian languages. *Vocal Fold Physiology: Contemporary Research and Clinical Issues*, edited by Diane M. Bless and James H. Abbs, San Diego: College Hill Press, 344–350.

CERCVADZE, I. I. 1967. Andijskij jazyk. *Iberijsko-kavkazskie jazyki*, *Jazyki narodov SSSR*, vol. 4, edited by E. A. Bokarev and K. V. Lomtatidze, Moscow: Akademija Nauk SSSR, 276–292.

CHAO, YUEN REN. 1970. The Changchow dialect. *Journal of the American Oriental Society* 90(1):45–56.

CHARACHIDZÉ, GEORGES. 1981. *Grammaire de la langue avar*. Paris: Éditions Jean-Favard.

CHEN, CHUN-MEI. 2006. *A Comparative Study on Formosan Phonology: Paiwan and Budai Rukai*. Ph.D. thesis, University of Texas at Austin, Austin, TX.

CHOMSKY, NOAM and MORRIS HALLE. 1968. *The sound pattern of English*. New York: Harper & Row.

CINCIUS, VERA IVANOVNA. 1982. *Negidal'skij jazyk*. Leningrad: Nauka.

CLEMENTS, GEORGE NICK. 1985. The geometry of phonological features. *Phonology Yearbook* 2:225–252.

CLEMENTS, GEORGE NICK and ELIZABETH HUME. 1995. The internal organization of speech sounds. *Handbook of Phonological Theory*, edited by John Goldsmith, Oxford, UK: Blackwell, 245–306.

COLARUSSO, JOHN. 1988. *The Northwest Caucasian Languages: A Phonological Survey*. Outstanding Dissertations in Linguistics, New York: Garland Publishing.

COLARUSSO, JOHN. 1989. East Circassian (Kabardian dialect). *The Northwest Caucasian Languages*, vol. 2, edited by B. George Hewitt, Delmar, NY: Caravan Books, 261–355.

COLARUSSO, JOHN. 1992. *A Grammar of the Kabardian Language*. University of Calgary Press.

COLE, PETER. 1982. *Imbabura Quechua*, *Lingua Descriptive Studies*, vol. 5. Amsterdam: North-Holland Publishing Company.

COLLINS, RAYMOND L. and BETTY PETRUSKA. 1979. *Dinak'i (Our Words): Upper Kuskokwim Athabaskan Junior Dictionary*. Anchorage, AK: National Bilingual Materials Development Center, Rural Education Affairs, University of Alaska.

COOK, EUNG-DO. 1981. Athapaskan linguistics: Proto-Athapaskan phonology. *Annual Review of Anthropology* 10:253–273.

COOK, EUNG-DO. 1984. *A Sarcee Grammar*. Vancouver, BC: University of British Columbia Press.

COOK, EUNG-DO. 2006. The patterns of consonantal acquisition and change in Chipewyan. *International Journal of American Linguistics* 72(2):236–263.

CRAIG, COLETTE GRINEVALD. 1977. *The Structure of Jacaltec*. Austin, TX: University of Texas Press.

CRASS, JOACHIM. 2002. Ejectives and pharyngeal fricatives: Two features of the Ethiopian language area. *Ethiopian Studies at the End of the Second Millennium: Proceedings of the XIVth International Conference of Ethiopian Studies*, edited by Baye Yimam; Richard Pankhurst; David Chapple; Yonas Admassu; Alula Pankhurst; and Berhanu Teferra, Addis Ababa: Institute of Ethiopian Studies, 1679–1691.

CZAYKOWSKA-HIGGINS, EWA. 1987. Characterizing tongue root behavior. Ms. MIT.

CZAYKOWSKA-HIGGINS, EWA. 2004. The morphological and phonological status of Nxaʔamxcín lexical suffixes. *Studies in Salish Linguistics in Honor of M. Dale Kinkade*, edited by Donna Gerdts and Lisa Matthewson, Missoula, MT: University of Montana, no. 17 in University of Montana Occasional Papers in Linguistics, 72–99.

CZAYKOWSKA-HIGGINS, EWA and M. DALE KINKADE. 1998. Salish languages and linguistics. *Salish Languages and Linguistics: Theoretical and Descriptive Perspectives*, edited by Ewa Czaykowska-Higgins and M. Dale Kinkade, Berlin: Mouton de Gruyter, 1–68.

DAVIDSON, MATTHEW. 2002. *Studies in Southern Wakashan (Nootkan) Grammar*. Ph.D. thesis, SUNY Buffalo, Buffalo, NY.

DAVIS, JOHN H. 1970. Notes on Mainland Comox phonology. *International Conference on Salish and Neighbouring Languages*, vol. 5, Vancouver, BC: University of British Columbia Working Papers in Linguistics.

DAVIS, STUART. 1995. Emphasis spread in Arabic and grounded phonology. *Linguistic Inquiry* 26(3):465–498.

DAY, CHRISTOPHER. 1973. *The Jacaltec Language*, *Indiana University Publications Language Science Monographs*, vol. 12. Bloomington, IN: Mouton.

DE BUSSER, RIK L. J. 2009. *Towards a Grammar of Takivatan Bunun: Selected Topics*. Ph.D. thesis, La Trobe University, Bundoora, Victoria.

DE LA ROCHA, LUIS ALBERTO. 1987. Relación sumaria sobre la escritura de la lengua quechua de Bolivia. *Ponencias sobre los fundamentos del uso de las cinco vocales*, Cuzco: Academia Peruana Mayor de la Lengua Quechua, 19–40.

DE REUSE, WILLEM JOSEPH. 1994. *Siberian Yupik Eskimo: The Language and Its Contacts with Chukchi*. Studies in Indigenous Languages of the Americas, Salt Lake City: University of Utah Press.

DELATTRE, PIERRE. 1971. Pharyngeal features in the consonants of Arabic, German, Spanish, French, and American English. *Phonetica* 23:129–155.

DELHEURE, JEAN. 1984. *Dictionnaire mozabite-français*. Paris: SELAF.

DELHEURE, JEAN. 1987. *Dictionnaire ouargli-français*. Paris: SELAF.

DEŠERIEV, JU. D. 1967. Xinalugskij jazyk. *Iberijsko-kavkazskie jazyki*, *Jazyki narodov SSSR*, vol. 4, edited by E. A. Bokarev and K. V. Lomtatidze, Moscow: Akademija Nauk SSSR, 659–675.

DITTRICH, RICARDA and GESKE REIBISCH. 2006. An acoustic study of /r/-vocalization in word-final position. *Institute of Phonetics and Digital Speech Processing, University of Kiel, Working Papers (AIPUK)* 37:19–26.

DIXON, ROBERT M. W. 2002. *Australian Languages*. Cambridge, UK: Cambridge University Press.

DOAK, IVY G. 1997. *Coeur d'Alene Grammatical Relations*. Ph.D. thesis, University of Texas at Austin, Austin, TX.

DOMBROWSKY-HAHN, KLAUDIA. 1999. *Phénomènes de contact entre les langues minyanka et bambara (Sud du Mali)*. Cologne: Köppe.

DRESHER, B. ELAN. 2009. *The Contrastive Hierarchy in Phonology*. Cambridge, UK: Cambridge University Press.

DUL'ZON, A. P. 1966. Čulymsko-tjurkskij jazyk. *Tjurkskie jazyki*, *Jazyki narodov SSSR*, vol. 2, edited by N. A. Baskakov, Moscow: Akademija Nauk SSSR, 446–466.

DUM-TRAGUT, JASMINE. 2009. *Armenian: Modern Eastern Armenian*. Philadelphia: John Benjamins.

EDELMAN, D. I. and LEILA R. DODYKHUDOEVA. 2009. The Pamir languages. *The Iranian Languages*, edited by Gernot Windfuhr, New York: Routledge, 773–786.

EDMONDSON, JEROLD A. and HUANG TUNG-CHIOU. 2004. Phonological strengthening in Hsiukuluan Amis. *Papers from the Eleventh Annual Meeting of the Southeast Asian Linguistics Society*, edited by Somsonge Burusphat, Tempe, AZ: Arizona State University, Program for Southeast Asian Studies, 263–273.

EDMONDSON, JEROLD A.; JOHN H. ESLING; and JIMMY G. HARRIS. 2004. Supralaryngeal cavity shape, linguistic register, and other phonetic features of Somali. Available at http://www.uta.edu/faculty/jerry/somali.pdf.

EDMONDSON, JEROLD A.; JOHN H. ESLING; JIMMY G. HARRIS; and HUANG TUNG-CHIOU. 2005. A laryngoscopic study of glottal and epiglottal/pharyngeal stop and continuant articulations in Amis – an Austronesian language of Taiwan. Ms.

ELMENDORF, WILLIAM W. 1990. Chemakum. *Handbook of North American Indians: Northwest Coast*, vol. 7, edited by William Sturtevant, Washington, DC: Smithsonian Institution, vol. 7, 438–440.

ENGLAND, NORA C. 1983. *A Grammar of Mam, a Mayan Language*. Austin, TX: University of Texas Press.

ERWIN, WALLACE M. 2004. *A Short Reference Grammar of Iraqi Arabic*. Washington, DC: Georgetown University Press. Re-issue of original 1963 work.

ESLING, JOHN H. 1996. Pharyngeal consonants and the aryepiglottic sphincter. *Journal of the International Phonetic Association* 26(2):65–88.

ESLING, JOHN H. 1997. Pharyngeal approximants, fricatives, trills, and stops. *Working Papers of the Linguistics Circle of the University of Victoria* 14:1–12.

ESLING, JOHN H. 1999. The IPA categories “pharyngeal” and “epiglottal”: Laryngoscopic observations of pharyngeal articulations and larynx height. *Language and Speech* 42(4):349–372.

ESLING, JOHN H. 2005. There are no back vowels: The laryngeal articulator model. *The Canadian Journal of Linguistics* 50(1):13–44.

ESLING, JOHN H. 2010. Phonetic notation. *The Handbook of Phonetic Sciences*, edited by William J. Hardcastle; John Laver; and Fiona E. Gibbon, New York: John Wiley & Sons, 678–702, 2nd edn.

FARUDI, ANNAHITA and M. DOUSTDAR TOOSARVANDANI. 2004. The Dari language project, 2004 fieldwork endeavor summary of findings. URL: http://linguistics.berkeley.edu/∼dari/2004_summary_of_findings.pdf.

FERGUSON, CHARLES. 1970. The Ethiopian language area. *The Journal of Ethiopian Studies* 8(2):67–80.

FERGUSON, CHARLES. 1976. The Ethiopian language area. *Language in Ethiopia*, edited by M. L. Bender; J. D. Bowen; R. L. Cooper; and C. A. Ferguson, Oxford: Oxford University Press, 63–76.

FISHER, W. B. 1968. Physical geography. *The Land of Iran*, *The Cambridge History of Iran*, vol. 1, edited by W. B. Fisher, Cambridge, UK: Cambridge University Press, 3–110.

FITCH, W. TECUMSEH and JAY GIEDD. 1999. Morphology and development of the human vocal tract: A study using magnetic resonance imaging. *Journal of the Acoustical Society of America* 106(3):1511–1522.

FLEMMING, EDWARD. 2001. Scalar and categorical phenomena in a unified model of phonetics and phonology. *Phonology* 18(1):7–44.

FLEMMING, EDWARD. 2005. Deriving natural classes in phonology. *Lingua* 115:287–309.

FLEMMING, EDWARD; PETER LADEFOGED; and SARAH THOMASON. 2008. Phonetic structures of Montana Salish. *Journal of Phonetics* 36(3):423–536.

FORTESCUE, MICHAEL. 1984. *West Greenlandic*. London: Croom Helm.

GALLAGHER, GILLIAN. 2007. Diachronic and synchronic pharyngealization in West Greenlandic. *Proceedings of the Workshop in General Linguistics*, *LSO Working Papers in Linguistics*, vol. 7, edited by Rebecca Shields, Madison, WI: Linguistics Student Organization, University of Wisconsin, Madison, 95–108.

GALLOWAY, BRENT D. 1983. A look at Nooksack phonology. *International Conference on Salish and Neighbouring Languages*, vol. 18, Vancouver, BC: University of British Columbia Working Papers in Linguistics, vol. 18, 80–132.

GALLOWAY, BRENT D. 1993. *A Grammar of Upriver Halkomelem*, *University of California Publications in Linguistics*, vol. 96. Berkeley, CA: University of California Press.

GANIEVA, F. A. 2002. *Xinalugsko-russkij slovar'*. Maxačkala, Russia: Dagestanskij Naučnyj Centr RAN.

GAPRINDAŠVILI, SHOTA GERASIMOVIČ. 1966. *Fonetika Darginskogo Jazyka*. Tbilisi: Mecniereba.

GARAY, ANA FERNANDEZ. 1998. *El Tehuelche: Una Lengua en Vías de Extinción*. Valdivia, Chile: Estudios Filológicos.

GARBELL, IRENE. 1964. 'flat' words and syllables in Jewish East New Aramaic of Persian Azerbaijan and the contiguous districts: A problem of multilingualism. *Studies in Egyptology and Linguistics In Honour of H. J. Polotsky*, edited by Haiim B. Rosén, Jerusalem: Israel Exploration Society, 86–103.

GARBELL, IRENE. 1965. *The Jewish Neo-Aramaic Dialect of Persian Azerbaijan: Linguistic Analysis and Folkloristic Texts*. The Hague: Mouton de Gruyter.

GARRETT, ANDREW. 1991. Indo-European reconstruction and historical methodologies. *Language* 67(4):790–804. Review of *The New Sound of Indo-European: Essays in Phonological Reconstruction* by Theo Vennemann.

GASSER, EMILY and CLAIRE BOWERN. 2014. Revisiting phonotactic generalizations in Australian languages. *Supplemental Proceedings of Phonology 2013*, edited by John Kingston; Claire Moore-Cantwell; Joe Pater; and Robert Staubs, Washington, DC: Linguistic Society of America.

GEORG, STEFAN. 2007. *A Descriptive Grammar of Ket (Yenisei-Ostyak): Part I*. Kent, UK: Global Oriental.

GHAZELI, SALEM. 1977. *Back Consonants and Backing Coarticulation in Arabic*. Ph.D. thesis, University of Texas at Austin, Austin, TX.

GODDARD, PLINY E. 1909. *Kato Texts*. Berkeley, CA: University of California Press.

GODDARD, PLINY E. 1912. *Elements of the Kato language*. Berkeley, CA: University of California Press.

GODDARD, PLINY E. 1923. Wailaki texts. *International Journal of American Linguistics* 2:77–135.

GOLDSMITH, JOHN. 1976. *Autosegmental Phonology*. Outstanding Dissertations in Linguistics, New York: Garland Press.

GOLLA, VICTOR. 1976. Tututni (Oregon Athapaskan). *International Journal of American Linguistics* 42:217–227.

GORDON, KENT H. 1976. *Phonology of Dhangar-Kurux*. Kathmandu, Nepal: Tribhuvan University Press.

GORDON, MATTHEW. 2001. Laryngeal timing and correspondence in Hupa. *UCLA Working Papers in Linguistics* 7:1–70.

GORDON, MATTHEW; BRIAN POTTER; JOHN DAWSON; WILLEM DE REUSE; and PETER LADEFOGED. 2001. Phonetic structures of Western Apache. *International Journal of American Linguistics* 67(4):415–448.

GORELOVA, LILIYA M. 2002. *Manchu Grammar*. Leiden, Netherlands: Brill.

GRAFF, PETER; PAUL MARTY; and DONCA STERIADE. 2013. French glides after C-liquid: The effect of contrast distinctiveness. Presentation at UC Berkeley Phonetics and Phonology Forum.

GRAGG, GENE B. 1997. Ge'ez (Ethiopic). *The Semitic Languages*, edited by Robert Hetzron, London: Routledge, 242–262.

GRAGG, GENE B. and TERFA KUMSA. 1982. *Oromo Dictionary*, *Committee on Northeast African Studies*, vol. 12. East Lansing, MI: African Studies Center of Michigan State University.

GREENBERG, JOSEPH H. 1963. *The Languages of Africa*. Bloomington, IN: Indiana University Press.

GRJUNBERG, A. L. 1966. Tatskij jazyk. *Indoevropejskie jazyki*, *Jazyki narodov SSSR*, vol. 1, edited by V. V. Vinogradov, Moscow: Akademija Nauk SSSR, 281–301.

GRUBB, DAVID M. 1977. *A Practical Writing System and Short Dictionary of Kwakw'ala (Kwakiutl)*. National Museum of Man Mercury Series, Ottawa: Canadian Ethnology Service.

GRUZDEVA, EKATERINA. 1998. *Nivkh*. No. 111 in Languages of the World: Materials, Munich: Lincom Europa.

GUDAVA, T. E. 1967. Botlixskij jazyk. *Iberijsko-kavkazskie jazyki*, *Jazyki narodov SSSR*, vol. 4, edited by E. A. Bokarev and K. V. Lomtatidze, Moscow: Akademija Nauk SSSR, 293–306.

GÜLDEMANN, TOM. 1997. The Kalahari Basin as an object of areal typology: A first approach. *Khoisan Forum, Working Papers 3*, Cologne: Institut für Afrikanistik, Universität zu Köln, 2–36.

GÜLDEMANN, TOM. 2001. Phonological regularities of consonant systems across khoisan lineages. *University of Leipzig Papers on Africa, Language and Literatures*, University of Leipzig.

GÜLDEMANN, TOM. 2006. "khoisan" linguistic classification in the light of genetic, anthropological, and geographical evidence in southern Africa. Handout from talk given at the 2nd International Symposium on Khoisan Languages and Linguistics, Riezlern. Handout available at http://wwwstaff.eva.mpg.de/∼gueldema/pdf/2006RiezlernHandout.pdf.

GÜLDEMANN, TOM. 2013a. Kwadi. *The Khoesan Languages*, edited by Rainer Vossen, London: Routledge, 87–89.

GÜLDEMANN, TOM. 2013b. Southern Khoesan (Tuu). *The Khoesan Languages*, edited by Rainer Vossen, London: Routledge, 75–84.

GUREVICH, NAOMI. 2013. *Lenition and Contrast: The Functional Consequences of Certain Phonetically Conditioned Sound Changes*. Outstanding Dissertations in Linguistics, New York: Routledge.

GUTT, ERNST-AUGUST. 1983. Studies in the phonology of Silti. *Journal of Ethiopian Studies* 16:37–74.

HAACKE, WILFRID H. G. 2013. Namibian Khoekhoe and !Gora. *The Khoesan Languages*, edited by Rainer Vossen, New York: Routledge, 51–56.

HACOPIAN, NARINEH. 2003. A three-way VOT contrast in final position: Data from Armenian. *Journal of the International Phonetic Association* 33(1):51–80.

HAJDA, YVONNE. 1990. Southwestern Coast Salish. *Handbook of North American Indians: Northwest Coast*, vol. 7, edited by William Sturtevant, Washington, DC: Smithsonian Institution, vol. 7, 503–517.

HALL, TRACY ALAN. 1997. *The Phonology of Coronals*. Philadelphia: John Benjamins.

HALLE, MORRIS. 1995. Feature geometry and feature spreading. *Linguistic Inquiry* 26(1):1–46.

HALLE, MORRIS and GEORGE NICK CLEMENTS. 1983. *Problem Book in Phonology: A Workbook for Introductory Courses in Linguistics and in Modern Phonology*. Cambridge, MA: MIT Press.

HALLE, MORRIS and KENNETH STEVENS. 1969. On the feature [advanced tongue root]. *MIT Research Laboratory of Electronics Quarterly Progress Report* 94:209–215.

HALLE, MORRIS; BERT VAUX; and ANDREW WOLFE. 2000. On feature spreading and the representation of place of articulation. *Linguistic Inquiry* 31(3):387–444.

HANSSON, GUNNAR ÓLAFUR. 2001. *Theoretical and Typological Issues in Consonant Harmony*. Ph.D. thesis, University of California, Berkeley, Berkeley, CA.

HANSSON, GUNNAR ÓLAFUR. 2007. On the evolution of consonant harmony: The case of secondary articulation agreement. *Phonology* 24:77–120.

HANSSON, GUNNAR ÓLAFUR. 2010. *Consonant Harmony: Long-Distance Interaction in Phonology*. University of California Publications in Linguistics, Berkeley, CA: University of California Press.

HARDMAN, MARTHA J. 1983. *Jaqaru*. Lima, Perú: Instituto de Estudios Peruanos.

HARDMAN, MARTHA J. 2000. *Jaqaru*, *Languages of the World: Materials*, vol. 183. Munich: Lincom Europa.

HARDMAN, MARTHA J.; JUANA VÁSQUEZ; JUAN DE DIOS YAPITA; LUCY THERINA BRIGGS; NORA C. ENGLAND; and LAURA MARTIN. 1988. *Aymara: Compendio de Estructura Fonológica y Gramatical*. La Paz, Bolivia and Gainesville, FL: Instituto de Lengua y Cultura Aymara and The Aymara Foundation, Inc., 1st edn. Translation of *Outline of Aymara Phonological and Grammatical Structure*, 1974.

HARGUS, SHARON. 1988. *The Lexical Phonology of Sekani*. New York: Garland Publishing.

HARGUS, SHARON. 1991. Deg Hit'an conjugation prefix allomorphy. Ms. with comments from Jeff Leer. URL: http://www.uaf.edu/anla/item.xml?id=IK982H1991a.

HARGUS, SHARON and VIRGINIA BEAVERT. 2002. Predictable versus underlying vocalism in Yakima Sahaptin. *International Journal of American Linguistics* 68(3):316–340.

HARRELL, R. S. 1957. *The Phonology of Colloquial Egyptian Arabic*. New York: American Council of Learned Societies.

HARRIS, ALICE C. 1991. Mingrelian. *The Kartvelian Languages*, *The Indigenous Languages of the Caucasus*, vol. 1, edited by Alice C. Harris, Delmar, NY: Caravan Books, 313–394.

HARRIS, ALICE C. 2002. *Endoclitics and the Origins of Udi Morphosyntax*. Oxford, UK: Oxford University Press.

HARRIS, JAMES. 1969. *Spanish Phonology*. Cambridge, MA: MIT Press.

HARRIS, JOHN and EDMUND GUSSMANN. 2002. Word-final onsets. *University College London Working Papers in Linguistics*, vol. 14, edited by Ad Neeleman and Reiko Vermeulen, London, vol. 14, 1–42.

HARRISON, K. DAVID. 2000. *Topics in the Phonology and Morphology of Tuvan*. Ph.D. thesis, Yale University, New Haven, CT.

HASPELMATH, MARTIN. 1993. *A Grammar of Lezgian*. New York: Mouton de Gruyter.

HAYES, BRUCE. 2009. *Introductory Phonology*. Malden, MA: Blackwell.

HAYNIE, HANNAH J. 2012. *Topics in the History and Geography of California Languages*. Ph.D. thesis, University of California, Berkeley, Berkeley, CA.

HAYWARD, K. M. and RICHARD J. HAYWARD. 1989. 'Guttural': Arguments for a new distinctive feature. *Transactions of the Philological Society* 87(2):179–193.

HAYWARD, RICHARD J. 1978. Bayso revisited: Some preliminary linguistic observations. *Bulletin of the School of Oriental and African Studies, University of London* 41(3):539–570.

HAYWARD, RICHARD J. 1984. *The Arbore Language: A First Investigation Including a Vocabulary*. Hamburg: Helmut Buske Verlag.

HAYWARD, RICHARD J. 1990. Notes on the Aari language. *Omotic Language Studies*, edited by Richard J. Hayward, London: University of London, School of Oriental and African Studies, 425–493.

HEAP, LYNN M. 1997. Acoustic analysis of pharyngeal approximants, fricatives, trills, and stops. *Working Papers of the Linguistics Circle of the University of Victoria* 13–22.

HEATH, JEFFREY. 2005. *A Grammar of Tamashek (Tuareg of Mali)*. Berlin: Mouton de Gruyter.

HEBB, DONALD O. 1949. *The Organization of Behavior: A Neuropsychological Theory*. New York: Wiley.

HEINE, BERND. 1981. *The Waata Dialect of Oromo: Grammatical Sketch and Vocabulary*, *Language and Dialect Atlas of Kenya*, vol. 4. Berlin: Dietrich Reimer Verlag.

HELIMSKI, EUGENE. 1998. Selkup. *The Uralic Languages*, edited by Daniel Abondolo, London: Routledge, 548–579.

HERZALLAH, RUKAYYAH S. 1991. *Aspects of Palestinian Arabic Phonology: A Non-Linear Approach*. Ph.D. thesis, Cornell University, Ithaca, NY.

HETZRON, ROBERT. 1969. *The Verbal System of Southern Agaw*, *University of California Publications in Near Eastern Studies*, vol. 12. Berkeley, CA: University of California Press.

HETZRON, ROBERT. 1972. *Ethiopian Semitic: Studies in Classification*. Manchester: Manchester University Press.

HETZRON, ROBERT. 1977. *The Gunnän-Gurage Languages*. Naples: Instituto Orientale di Napoli.

HOBERMAN, ROBERT D. 1985. The phonology of pharyngeals and pharyngealization in Pre-Modern Aramaic. *Journal of the American Oriental Society* 105(2):221–231.

HOBERMAN, ROBERT D. 1988. Emphasis harmony in a Modern Aramaic dialect. *Language* 64(1):1–26.

HOIJER, HARRY. 1946. Chiricahua apache. *Linguistic Structures of Native America*, edited by Cornelius Osgood, New York: Viking Fund, 55–84.

HOIJER, HARRY. 1966. Galice Athapaskan: A grammatical sketch. *International Journal of American Linguistics* 32(4):320–327.

HOLISKY, DEE ANN. 1991. Laz. *The Kartvelian Languages*, *The Indigenous Languages of the Caucasus*, vol. 1, edited by Alice C. Harris, Delmar, NY: Caravan Books, 395–472.

HOLISKY, DEE ANN and RUSUDAN GAGUA. 1994. Tsova-Tush (Batsbi). *North East Caucasian Languages, Part 2*, *The Indigenous Languages of the Caucasus*, vol. 4, edited by Rieks Smeets, Delmar, NY: Caravan Books, 147–212.

HOLMER, ARTHUR J. 1996. *A Parametric Grammar of Seediq*, *Travaux de l'Institut de linguistique de Lund*, vol. 30. Lund, Sweden: Lund University Press.

HOLTON, GARY. 2000. *The Phonology and Morphology of the Tanacross Athabaskan Language*. Ph.D. thesis, University of California, Santa Barbara, Santa Barbara, CA.

HOMBERT, JEAN-MARIE. 1984. Tonogenesis revisited. *Pholia* 1:77–86.

HONKEN, HENRY. 2013a. Eastern ǂhoan. *The Khoesan Languages*, edited by Rainer Vossen, London: Routledge, 84–87.

HONKEN, HENRY. 2013b. Genetic relationships: An overview of the evidence. *The Khoesan Languages*, edited by Rainer Vossen, London: Routledge, 13–22.

HOWE, DARIN. 2000. *Oowekyala Segmental Phonology*. Ph.D. thesis, University of British Columbia, Vancouver, BC.

HYMAN, LARRY M. 1972. *A Phonological Study of Fe'fe'-Bamileke*. Ph.D. thesis, University of California, Los Angeles, Los Angeles.

HYMAN, LARRY M. 1973. The feature [grave] in phonological theory. *Journal of Phonetics* 1(4):329–337.

IBANEZ, ESTEBAN. 1959. *Diccionario Español - Senhayi (Dialecto Bereber de Senhaya de Serair)*. Madrid: Instituto de Estudios Africanos.

IBRAGIMOV, G. X. 1978. *Rutul'skij jazyk*. Moscow: Nauka.

IBRAGIMOV, G. X. 1990. *Tsaxurskij jazyk*. Moscow: Nauka.

INGHAM, BRUCE. 1994. *Najdi Arabic: Central Arabian*, *London Oriental and African Language Library*, vol. 1. Philadelphia: John Benjamins.

JACOBSEN, WILLIAM H. 1969. Origin of the Nootka pharyngeals. *International Journal of American Linguistics* 35(2):125–153.

JAKOBSON, ROMAN. 1962. Mufaxxama: The 'emphatic' phonemes in Arabic. *Phonological Studies*, *Selected Writings*, vol. 1, edited by Roman Jakobson, The Hague: Mouton and Co., 510–522.

JAKOBSON, ROMAN and MORRIS HALLE. 1956. *Fundamentals of Language*. The Hague: Mouton.

JAKOBSON, ROMAN; GUNNAR FANT; and MORRIS HALLE. 1952. *Preliminaries to Speech Analysis*. Cambridge, MA: MIT Press.

JASTROW, OTTO. 1997. The Neo-Aramaic languages. *The Semitic Languages*, edited by Robert Hetzron, London: Routledge, 334–377.

JETTÉ, JULES and ELIZA JONES. 2000. *Koyukon Athabaskan Dictionary*. Fairbanks, AK: Alaska Native Language Center.

JOHANSON, LARS. 1998. The history of Turkic. *The Turkic Languages*, edited by Lars Johanson and Éva Ágnes Csató, New York: Routledge, 81–125.

JOHNSTONE, THOMAS M. 1967. *Eastern Arabian Dialect Studies*. Oxford, UK: Oxford University Press.

JOHNSTONE, THOMAS M. 1977. *Ḥarsūsi Lexicon*. Oxford, UK: Oxford University Press.

JOHNSTONE, THOMAS M. 1981. *Jibbāli Lexicon*. Oxford, UK: Oxford University Press.

KARI, JAMES. 2007. *Dena'ina Topical Dictionary*. Fairbanks, AK: Alaska Native Language Center.

KARPOV, V. G. 1966. Xakasskij jazyk. *Tjurkskie jazyki*, *Jazyki narodov SSSR*, vol. 2, edited by N. A. Baskakov, Moscow: Akademija Nauk SSSR, 428–445.

KENNEDY, DOROTHY and RANDY BOUCHARD. 1990. Northern Coast Salish. *Handbook of North American Indians: Northwest Coast*, vol. 7, edited by William Sturtevant, Washington, DC: Smithsonian Institution, vol. 7, 441–452.

KHALILOVA, ZAIRA. 2009. *A Grammar of Khwarshi*. Utrecht: LOT.

KHOJAYORI, NASRULLO and MIKAEL THOMPSON. 2009. *Tajiki Reference Grammar for Beginners*. Washington, DC: Georgetown University Press.

KIBRIK, A. E.; S. V. KODZASOV; I. P. OLOVJANNIKOVA; and D. S. SAMEDOV. 1977. *Opyt strukturnogo opisanija arčinskogo jazyka*, vol. 1. Moscow: Izdatel'stvo Moskovskogo Universiteta.

KIBRIK, ALEKSANDR. 1996. *Godoberi*. Newcastle, UK: Lincom Europa.

KIBRIK, ALEKSANDR E. 1994. Archi. *The Northeast Caucasian Languages, Part 2*, *The Indigenous Languages of the Caucasus*, vol. 4, Delmar, NY: Caravan Books, 297–365.

KIBRIK, ALEKSANDR EVGEN'EVIČ and SANDRO VASIL'EVIČ KODZASOV. 1990. *Sopostavitel'noe izučenie dagestanskix jazykov. Imja. Fonetika.* Moscow: Moscow State University.

KIBRIK, ALEKSANDR EVGEN'EVIČ; SANDRO VASIL'EVIČ KODZASOV; and IRINA ANATOL'EVNA MURAV'EVA. 2000. *Jazyk i fol'klor aljutorcev*. Moscow: IMLI RAN Nasledie.

KIEFFER, CHARLES M. 2009. Parachi. *The Iranian Languages*, edited by Gernot Windfuhr, New York: Routledge, 693–720.

KIESSLING, ROLAND. 1994. *Eine Grammatik des Burunge*. Hamburg: Research and Progress Verlag.

Kiessling, Roland; Maarten Mous; and Derek Nurse. 2007. The Tanzanian Rift Valley area. *A Linguistic Geography of Africa*, edited by Bernd Heine and Derek Nurse, Cambridge, UK: Cambridge University Press, 186–227.

Kinkade, M. Dale. 1963. Phonology and morphology of Upper Chehalis: I. *International Journal of American Linguistics* 29(3):181–195.

Kinkade, M. Dale. 2004. *Cowlitz Dictionary and Grammatical Sketch*. No. 18 in University of Montana Occasional Papers in Linguistics, Missoula, MT: University of Montana.

Kiparsky, Paul. 1995. The phonological basis of sound change. *The Handbook of Phonological Theory*, edited by John Goldsmith, Cambridge, MA: Blackwell, 640–670.

Kirchner, Robert. 1998. *An Effort-Based Approach to Consonant Lenition*. Ph.D. thesis, University of California, Los Angeles, Los Angeles.

Kisseberth, Charles W. 1970. On the functional unity of phonological rules. *Linguistic Inquiry* 1(3):291–306.

Kogan, Leonid E. 1997. Tigrinya. *The Semitic Languages*, edited by Robert Hetzron, London: Routledge, 424–445.

Kossmann, Maarten G. 1999. *Essai sur la phonologie du proto-berbère*. Cologne: Rüdiger Köppe Verlag.

Kossmann, Maarten G. 2000. *Esquisse grammaticale du rifain oriental*. Paris: Peeters.

Krauss, Michael. 1979. Na-Dene and Eskimo-Aleut. *The Languages of Native America: A Historical and Comparative Assessment*, edited by Lyle Campbell and Marianne Mithun, Austin, TX: University of Texas Press, 803–901.

Krauss, Michael and Victor Golla. 1981. Northern Athapaskan languages. *Handbook of North American Indians: Subarctic*, vol. 6, edited by William C. Sturtevant, Washington, DC: Smithsonian Institution, 67–85.

Kuipers, Aert H. 1967. *The Squamish Language: Grammar, Texts, Dictionary*. Janua Linguarum, The Hague: Mouton.

Kuryłowicz, Jerzy. 1927. ə indoeuropéen et ḫ hittite. *Symbolae Grammaticae in Honorem Ioannis Rozwadowki*, Krakow: Gebethner and Wolff, 95–104.

Ladefoged, Peter. 1971. *Preliminaries to Linguistic Phonetics*. Chicago: University of Chicago Press.

Ladefoged, Peter and Ian Maddieson. 1996. *Sounds of the World's Languages*. Oxford, UK: Blackwell.

LANHAM, L. W. and D. P. HALLOWES. 1956. An outline of the structure of Eastern Bushman. *African Studies* 15(3):98–118.

LASS, ROGER. 1993. How real(ist) are reconstructions? *Historical Linguistics: Problems and Perspectives*, edited by Charles Jones, London: Longman, 156–189.

LAUFER, ASHER and THOMAS BAER. 1988. The emphatic and pharyngeal sounds in Hebrew and in Arabic. *Language and Speech* 31:181–205.

LAUFER, ASHER and IOVANNA D. CONDAX. 1981. The role of the epiglottis in speech. *Language and Speech* 24:39–62.

LESLAU, WOLF. 1956. *Étude descriptive et comparative du Gafat*. Paris: La Société de Linguistique de Paris.

LESLAU, WOLF. 1959. A preliminary description of Argobba. *Annales d'Ethiopie* 3(3):251–273.

LESLAU, WOLF. 1981. *Muher*. Ethiopians Speak: Studies in Cultural Background, Wiesbaden: Franz Steiner Verlag.

LESLAU, WOLF. 1983. *Chaha-Ennemor*, *Ethiopians Speak: Studies in Cultural Background*, vol. 5. Wiesbaden: Franz Steiner Verlag.

LESLAU, WOLF. 1995. *Reference Grammar of Amharic*. Wiesbaden: Harrassowitz.

LESLAU, WOLF. 1999. *Zway Ethiopic Documents: Grammar and Dictionary*. Wiesbaden: Harrassowitz.

LEVINSON, STEPHEN C. 1983. *Pragmatics*. Cambridge, UK: Cambridge University Press.

LEWIS, M. PAUL. 2009. *Ethnologue: Languages of the World*. Dallas, TX: SIL International. Online version: http://www.ethnologue.com/.

LEYEW, ZELEALEM. 2003. *The Kemantney Language: A Sociolinguistic and Grammatical Study of Language Replacement*. Cologne: Rüdiger Köppe Verlag.

LI, PAUL JEN-KUEI and SHIGERU TSUCHIDA. 2006. *Kavalan Dictionary*. Taipei: Academia Sinica.

LINDAU, MONA. 1978. Vowel features. *Language* 54(3):541–563.

LIONNET, FLORIAN. 2014. Doubly triggered harmony in Laal as subphonemic Agreement by Correspondence. *Supplemental Proceedings of Phonology 2013*, edited by John Kingston; Claire Moore-Cantwell; Joe Pater; and Robert Staubs, Washington, DC: Linguistic Society of America.

LU, YU-AN. 2007. UM infixation in Thao. Qualifying Paper, State University of New York at Stony Brook.

LYDALL, JEAN. 1976. Hamer. *The Non-Semitic Languages of Ethiopia*, edited by M. Lionel Bender, East Lansing, MI: African Studies Center of Michigan State University, 393–438.

LYMAN, THOMAS AMIS. 1979. *Grammar of Mong Njua*. Sattley, CA: Blue Oak Press.

MADDIESON, IAN; RAMAZAN RAJABOV; and AARON SONNENSCHEIN. 1996. The main features of Tsez phonetics. *UCLA Working Papers in Phonetics* 93:94–110.

MAGOMEDBEKOVA, Z. M. 1967. Axvaxskij jazyk. *Iberijsko-kavkazskie jazyki*, *Jazyki narodov SSSR*, vol. 4, edited by E. A. Bokarev and K. V. Lomtatidze, Moscow: Akademija Nauk SSSR, 336–350.

MAGOMEDBEKOVA, Z. M. 1971. *Karatinskij jazyk*. Tbilisi: Mecniereba.

MAGOMEDOV, A. G. 1966. Kumykskij jazyk. *Tjurkskie jazyki*, *Jazyki narodov SSSR*, vol. 2, edited by N. A. Baskakov, Moscow: Akademija Nauk SSSR, 194–212.

MAGOMEDOVA, P. T. 1999. *Čamalinsko-russkij slovar'*. Maxačkala, Russia: Dagestanskij Naučnyj Centr RAN.

MAGOMEDOVA, P. T. 2003. *Tindinsko-russkij slovar'*. Maxačkala, Russia: Dagestanskij Naučnyj Centr RAN.

MAGOMETOV, A. A. 1963. *Kubačinskij jazyk*. Tbilisi: Izdatel'stvo Akademii Nauk Gruzinskoj SSR.

MAGOMETOV, A. A. 1982. *Megebskij dialekt darginskogo jazyka*. Tbilisi: Mecniereba.

MAGOMETOV, ALEKSANDR AMAROVIČ. 1970. *Agul'skij jazyk*. Tbilisi, Georgia: Mecniereba.

MAISAK, TIMUR. 2008. The Agul language in its Daghestanian context. Handout from talk given at the Seminar on Noun Phrase Typology (TypoULM).

MALCHUKOV, ANDREI L. 1995. *Even*. Munich: Lincom Europa.

MASLOVA, ELENA. 2003a. *A Grammar of Kolyma Yukaghir*. Berlin: Mouton de Gruyter.

MASLOVA, ELENA. 2003b. *Tundra Yukaghir*. Munich: Lincom Europa.

MATTINA, ANTHONY. 1973. Colville grammatical structure. *University of Hawaii Working Papers in Linguistics* 5(4):i–154. University of Hawaii Dissertation.

MCCARTHY, JOHN. 2010. Agreement by correspondence without CORR constraints. Ms. University of Massachusetts, Amherst.

MCCARTHY, JOHN J. 1988. Feature geometry and dependency: A review. *Phonetica* 43:84–108.

McCarthy, John J. 1991. Semitic gutturals and distinctive feature theory. *Perspectives on Arabic Linguistics III: Papers from the Third Annual Symposium on Arabic Linguistics*, edited by Bernard Comrie and Mushira Eid, Philadelphia: John Benjamins, 63–91.

McCarthy, John J. 1994. The phonetics and phonology of Semitic pharyngeals. *Phonological Structure and Phonetic Form, Papers in Laboratory Phonology III*, edited by Patricia A. Keating, Cambridge, UK: Cambridge University Press, 191–233.

McDonough, Joyce. 2003. *The Navajo Sound System*. Dordrecht, Netherlands: Kluwer Academic Publishers.

McDonough, Joyce. 2013. Dene speech atlas. Online atlas of recordings of Northern Athabaskan (Dene) languages funded by the NSF and available at http://www.ling.rochester.edu/DeneSpeechAtlas/.

McFarland, Teresa A. 2009. *The Phonology and Morphology of Filomeno Mata Totonac*. Ph.D. thesis, University of California, Berkeley, Berkeley, CA.

Menovščikov, Georgij Alekseevič. 1964. *Jazyk sirenikskix èskimosov: Fonetika, očerk morfologii, teksty i slovar'*. Leningrad: Nauka.

Menovščikov, Georgij Alekseevič. 1975. *Jazyk naukanskix èskimosov*. Leningrad: Nauka.

Michael, Lev; Tammy Stark; and William Chang. 2013. South american phonological inventory database (saphon). Survey of California and Other Indian Languages Digital Resource. Berkeley: University of California.

Michael, Lev D.; Tammy Stark; and William Chang. 2012. Phonological inventory of Xiriâna. In *Phonological Inventory Database*. Survey of California and Other Indian Languages Digital Resource. Berkeley, CA: University of California.

Mielke, Jeff. 2008. *The Emergence of Distinctive Features*. Oxford: Oxford University Press. P-base accessed via http://137.122.133.199/∼Jeff/pbase/.

Miller, Amanda L. 2013. Northern Khoesan. *The Khoesan Languages*, edited by Rainer Vossen, New York: Routledge, 45–51.

Miller, Amanda L.; Johanna Brugman; Bonny Sands; Levi Namaseb; Mats Exeter; and Chris Collins. 2007. The sounds of N|uu: Place and airstream contrasts. *Working Papers of the Cornell Phonetics Lab* 16:101–160.

Miller-Ockhuizen, Amanda. 2003. *The Phonetics and Phonology of Gutturals: A Case Study from Ju|'hoansi*. Outstanding Dissertations in Linguistics, New York: Routledge.

Mithun, Marianne. 1999. *The Languages of Native North America*. Cambridge, UK: Cambridge University Press.

MOISIK, SCOTT. 2013. *The Epilarynx in Speech*. Ph.D. thesis, University of Victoria, Victoria, BC.

MOISIK, SCOTT and JOHN H. ESLING. 2011. The 'whole larynx' approach to laryngeal features. *ICPhS XVII*, Hong Kong, 1406–1409.

MONTLER, TIMOTHY. 1998. The major processes affecting Klallam vowels. *International Conference on Salish and Neighbouring Languages*, vol. 33, Vancouver, BC: University of British Columbia Working Papers in Linguistics, vol. 33, 366–373.

MORETON, ELLIOTT. 2008. Analytic bias and phonological typology. *Phonology* 25(1):83–127.

MOUS, MAARTEN. 1993. *A Grammar of Iraqw*. Hamburg: Helmut Buske Verlag.

MOUS, MAARTEN. 2003. *The Making of a Mixed Language: The Case of Ma'a/Mbugu*. Philadelphia: John Benjamins.

NAÏT-ZERRAD, KAMAL. 2001. *Grammaire moderne du kabyle: tajerrumt tatrart n teqbaylit*. Paris: Karthala.

NAKAGAWA, HIROSHI. 2006. *Aspects of the Phonetic and Phonological Structure of the G|ui Language*. Ph.D. thesis, University of the Witwatersrand, Johannesburg.

NAKAGAWA, HIROSHI. 2010. Phonotactics of disyllabic lexical morphemes in G|ui. *Working Papers in Corpus-Based Linguistics and Language Education* 5:23–31.

NAKAGAWA, HIROSI. 2013. ‖Gana subgroup. *The Khoesan Languages*, edited by Rainer Vossen, London: Routledge, 64–71.

NATER, HANK F. 1989. Some comments on the phonology of tahltan. *International Journal of American Linguistics* 55(1):25–42.

NAUMANN, CHRISTFRIED. Forthcoming. The phoneme inventory of Taa (West !Xoon dialect). In *Essays in Memory of Anthony Traill*, ed. by Rainer Vossen and Wilfrid H. G. Haacke.

NAWATA, TETSUO. 1981. *Baluchi*. Tokyo: Institute for the Study of Languages and Cultures of Asia and Africa, Tokyo University of Foreign Studies.

NEDJALKOV, IGOR. 1997. *Evenki*. New York: Routledge.

NEVIN, BRUCE E. 1998. *Aspects of Pit River Phonology*. Ph.D. thesis, University of Pennsylvania, Philadelphia.

NÍ CHIOSÁIN, MÁIRE and JAYE PADGETT. 1993. Inherent VPlace. Tech. Rep. LRC-93-09, Linguistics Research Center, University of California, Santa Cruz, Santa Cruz, CA.

NICHOLS, JOHANNA. 1992. *Linguistic Diversity in Space and Time*. Chicago: University of Chicago Press.

NICHOLS, JOHANNA. 2003. The Nakh-Daghestanian consonant correspondences. *Current Trends in Caucasian, East European and Inner Asian Linguistics: Papers in Honor of Howard I. Aronson*, edited by Dee Ann Holisky and Kevin Tuite, Philadelphia: John Benjamins, 207–264.

NICHOLS, JOHANNA. 2011. *Ingush Grammar*, *University of California Publications in Linguistics*, vol. 143. Berkeley, CA: University of California Press.

NICHOLS, JOHANNA and BALTHASAR BICKEL. 2009. The AUTOTYP genealogy and geography database: 2009 release. URL: `http://www.uni-leipzig.de/∼autotyp`.

NICHOLS, JOHANNA and ARBI VAGAPOV. 2004. *Chechen-English and English-Chechen Dictionary*. New York: RoutledgeCurzon.

NICOLAS, FRANCIS. 1953. *La langue berbère de Mauritanie*. Dakar: IFAN.

NIKOLAEVA, IRINA and MARIA TOLSKAYA. 2001. *A Grammar of Udihe*. Berlin: Mouton de Gruyter.

NORDBUSTAD, FRØYDIS. 1988. *Iraqw Grammar: An Analaytical Study of the Iraqw Language*. Berlin: Dietrich Reimer Verlag.

NOVIKOVA, KLAVDIJA ALEKSANDROVNA. 1960. *Očerki dialektov èvenskogo jazyka: Ol'skij govor, čast' 1*. Moscow: Akademija Nauk SSSR. Sketches of Even Dialects: Ola Dialect, Part 1.

OHALA, JOHN J. 1981. The listener as a source of sound change. *Papers from the Parasession on Language and Behavior, Proceedings of the Chicago Linguistic Society*, vol. 17, edited by Carrie S. Masek; Roberta A. Hendrick; and Mary Frances Miller, Chicago: Chicago Linguistic Society, 178–203.

OKADA, HIDEO. 1991. Japanese (Illustration of the IPA). *Journal of the International Phonetic Association* 21(2):94–96.

OQUENDO, LUÍS. 2004. La vibrante uvular y la aproximante labiodental en la lengua japreria como cultura fonológica. *Opción* 20(45):60–74.

OWENS, JONATHAN. 1984. *A Short Reference Grammar of Eastern Libyan Arabic*. Wiesbaden: Harrassowitz.

OWENS, JONATHAN. 1985. *A Grammar of Harar Oromo (Northeastern Ethiopia)*. Hamburg: Helmut Buske Verlag.

ÖZTOPÇU, KURTULUŞ. 2000. *Elementary Azerbaijani*. Santa Monica, CA: Şafak Offset.

PADGETT, JAYE. 1995. Partial class behavior and nasal place assimilation. *Proceedings of the Southwestern Optimality Theory Workshop (SWOT)*, *Coyote Working Papers*, vol. 5, edited by Keiichiro Suzuki and Dirk Elzinga, Tucson, AZ: University of Arizona Linguistics Circle, 145–183.

PADGETT, JAYE. 2002. Feature classes in phonology. *Language* 78(1):81–110.

PARKER, ENID M. and RICHARD J. HAYWARD. 1985. *An Afar-English-French Dictionary (with Grammatical Notes in English)*. London: University of London, School of Oriental and African Studies.

PENCE, ALAN. 1966. *Kunimaipa Phonology: Hierarchical Levels*, Canberra: Australian National University, *Pacific Linguistics, Series A*, vol. 7, 49–67.

PENFIELD, WILDER and THEODORE RASMUSSEN. 1950. *The Cerebral Cortex of Man*. New York: Macmillan.

PERKELL, JOSEPH S. 1980. Phonetic features and the physiology of speech production. *Language Production 1: Speech and Talk*, edited by B. Butterworth, New York: Academic Press, 337–372.

PETROVA, TAISIJA IVANOVNA. 1967. *Jazyk orokov (ul'ta)*. Leningrad: Nauka.

PILLINGER, STEVE and LETIWA GALBORAN. 1999. *A Rendille Dictionary: Including a Grammatical Outline and an English-Rendille Index*. Cologne: Rüdiger Köppe Verlag.

PRASSE, KARL-G.; GHOUBEÏD ALOJALY; and GHABDOUANE MOHAMED. 1998. *Lexique touareg-français*. Copenhagen: Museum Tusculanum Press.

PRENTICE, DAVID JOHN. 1971. *The Murut Languages of Sabah*, *Pacific Linguistics, Series C*, vol. 18. Canberra: Linguistic Circle of Canberra.

PRINCE, ALAN and PAUL SMOLENSKY. 1993. Optimality Theory: Constraint interaction in generative grammar. Ms., Rutgers University and University of Colorado, Boulder. RuCCS-TR-2. ROA 537-0802. ROA version from Aug. 2002.

PULLUM, GEOFFREY K. and WILLIAM A. LADUSAW. 1996. *Phonetic Symbol Guide*. Chicago: University of Chicago Press, 2nd edn.

R CORE TEAM. 2013. *R: A Language and Environment for Statistical Computing*. R Foundation for Statistical Computing, Vienna, Austria, URL `http://www.R-project.org`.

RANDOJA, TIINA KATHRYN. 1990. *The Phonology and Morphology of Halfway River Beaver*. Ph.D. thesis, University of Ottawa, Ottawa.

RASSADIN, VALENTIN IVANOVIČ. 1971. *Fonetika i leksika tofalarskogo jazyka*. Ulan-Udè: Akademija Nauk SSSR, Burjatskoe Knižnoe Izdatel'stvo.

RASTORGUEVA, V. S.; A. A. KERIMOVA; A. K. MAMEDZADE; L. A. PREIKO; and D. I. EDEL'MAN. 2012. *The Gilaki Language*. Studia Iranica Upsaliensia, Uppsala: Uppsala Universitet. Translation and expansion of *Giljanskij jazyk* by Ronald M. Lockwood.

Rath, John C. 1981. *A Practical Heiltsuk-English Dictionary With a Grammatical Introduction*, *National Museum of Man Mercury Series*, vol. 1. Ottawa: Canadian Ethnology Service.

Rau, Victoria Der-Hwa. 1992. *A Grammar of Atayal*. Ph.D. thesis, Cornell University, Ithaca, NY.

Raz, Shlomo. 1983. *Tigre Grammar and Texts*, *Afroasiatic Dialects*, vol. 4. Malibu, CA: Undena Publications.

Raz, Shlomo. 1997. Tigré. *The Semitic Languages*, edited by Robert Hetzron, London: Routledge, 446–456.

Recasens, Daniel and Maria Dolors Pallarès. 1999. A study of /ɾ/ and /r/ in the light of the "DAC" coarticulation model. *Journal of Phonetics* 27:143–169.

Rice, Keren. 1989. *A Grammar of Slave*. Berlin: Mouton de Gruyter.

Ridouane, Rachid. 2003. *Suites de Consonnes en Berbere Chleuh: Phonetique et Phonologie*. Ph.D. thesis, Université de la Sorbonne Nouvelle - Paris III, Paris.

Ridouane, Rachid. 2008. Syllables without vowels: Phonetic and phonological evidence from Tashlhiyt Berber. *Phonology* 25(2):321–359.

Rigsby, Bruce J. 1986. Gitksan grammar. Ms. University of Queensland, Australia.

Rodson, Barbara and Habibullah Tegey. 2009. Pashto. *The Iranian Languages*, edited by Gernot Windfuhr, New York: Routledge, 721–772.

Rood, David S. and Allan R. Taylor. 1996. Sketch of Lakhota, a Siouan language. *Handbook of North American Indians*, vol. 17, edited by Ives Goddard, Washington, DC: Smithsonian Institution, 440–482.

Rose, Sharon. 1996. Variable laryngeals and vowel lowering. *Phonology* 13:73–117.

Rose, Sharon and Rachel Walker. 2004. A typology of consonant agreement as correspondence. *Language* 80(3):475–531.

Ross, Malcolm. 2009. Proto Austronesian verbal morphology: A reappraisal. *Austronesian Historical Linguistics and Culture History: A Festschrift for Robert Blust*, edited by Alexander Adelaar and Andrew Pawley, Canberra: Pacific Linguistics Publishers, chap. 19, 295–326.

Ross, Malcolm. 2012. In defense of nuclear Austronesian (and against Tsouic). *Language and Linguistics* 13(6):1253–1330.

Rubin, Aaron D. 2008. The subgrouping of the Semitic languages. *Language and Linguistics Compass* 2(1):79–102.

RUBIN, AARON D. 2010. *The Mehri Language of Oman*, *Studies in Semitic Languages and Linguistics*, vol. 58. Leiden: Brill.

SADOCK, JEROLD M. 2003. *A Grammar of Kalaallisut (West Greenlandic Inuttut)*. Languages of the World: Materials, Munich: Lincom Europa.

SAEED, JOHN. 1999. *Somali*. Philadelphia: John Benjamins.

SAGEY, ELIZABETH. 1990. *The Representation of Features in Non-Linear Phonology: The Articulator Node Hierarchy*. Outstanding Dissertations in Linguistics, New York: Garland.

SASSE, HANS-JÜRGEN. 1982. *An Etymological Dictionary of Burji*. Hamburg: Helmut Buske Verlag.

SCHMIDT, KARL HORST. 1991. Svan. *The Kartvelian Languages*, *The Indigenous Languages of the Caucasus*, vol. 1, edited by Alice C. Harris, Delmar, NY: Caravan Books, 473–556.

SCHÖNIG, CLAUS. 1998. South Siberian Turkic. *The Turkic Languages*, edited by Lars Johanson and Éva Ágnes Csató, New York: Routledge, 403–416.

SCHULZE, WOLFGANG. 2000. *Northern Talysh*. Munich: Lincom Europa.

SHAHIN, KIMARY N. 2002. *Postvelar Harmony*. Amsterdam: John Benjamins.

SHOSTED, RYAN K. 2009. Origins of the voiceless uvular implosive in Q'anjob'al. Conference on the Endangered Languages of Central and North America. Salt Lake City, UT.

SHOSTED, RYAN K. and VAKHTANG CHIKOVANI. 2006. Standard Georgian. *Journal of the International Phonetic Association* 36:255–264.

SIMEONE-SENELLE, MARIE-CLAUDE. 1997. The Modern South Arabian languages. *The Semitic Languages*, edited by Robert Hetzron, London: Routledge, 378–423.

SKORIK, PETR JAKOVLEVIČ. 1961. *Grammatika čukotskogo jazyka*, vol. 1. Leningrad: Izdatel'stvo Akademii Nauk SSSR.

SKORIK, PETR JAKOVLEVIČ. 1968. Kerekskij jazyk. *Jazyki narodov SSSR*, vol. 5, edited by V. V. Vinogradov, Leningrad: Nauka, vol. 5, 310–333.

SMITH, KATHLEEN K. and WILLIAM M. KIER. 1989. Trunks, tongues, and tentacles: Moving with skeletons of muscle. *American Scientist* 77(1):28–35.

SOKOLOVA, V. S. 1953. *Očerki po fonetike iranskix jazykov*. Moscow: Izdatel'stvo Akademii Nauk SSSR.

SOLÉ, MARIA-JOSEP; LARRY M. HYMAN; and KEMMONYE C. MONAKA. 2010. More on postnasal devoicing: The case of Shekgalagari. *Journal of Phonetics* 38(4):604–615.

SPENCER, ANDREW. 1999. Chukchee, chapter 2: Phonology. Accessed via http://privatewww.essex.ac.uk/ spena/Chukchee/chapter2.html.

STACHOWSKI, MAREK and ASTRID MENZ. 1998. Yakut. *The Turkic Languages*, edited by Lars Johanson and Éva Ágnes Csató, New York: Routledge, 417–433.

STEWART, J. M. 1967. Tongue root position in Akan vowel harmony. *Phonetica* 16(4):185–204.

STORY, GILLIAN L. 1984. *Babine and Carrier Phonology: A Historically Oriented Study*. Arlington, TX: Summer Institute of Linguistics.

STROOMER, HARRY. 1995. *A Grammar of Boraana Oromo (Kenya)*. Cologne: Rüdiger Köppe Verlag.

SUMBATOVA, NINA R. and RASUL O. MUTALOV. 2003. *A Grammar of Icari Dargwa*. Lincom Europa.

SUNIK, OREST PETROVIČ. 1985. *Ul'čskij jazyk*. Leningrad: Nauka.

SUTTLES, WAYNE and BARBARA LANE. 1990. Southern Coast Salish. *Handbook of North American Indians: Northwest Coast*, vol. 7, edited by William Sturtevant, Washington, DC: Smithsonian Institution, vol. 7, 485–502.

SYLAK-GLASSMAN, JOHN. 2014. An emergent approach to the guttural natural class. *Supplemental Proceedings of Phonology 2013*, edited by John Kingston; Claire Moore-Cantwell; Joe Pater; and Robert Staubs, Washington, DC: Linguistic Society of America.

TALIBOV, B. B. 2007. *Buduxskij jazyk*. Moscow: Academia.

TAMBURRI WATT, LINDA; MICHAEL ALFORD; JEN CAMERON-TURLEY; CARRIE GILLON; and PETER JACOBS. 2000. Sḵwx̱wú7mesh (Squamish Salish) stress: A look at the acoustics of /a/ and /u/. *International Conference on Salish and Neighbouring Languages*, vol. 35, Vancouver, BC: University of British Columbia Working Papers in Linguistics, 199–217.

TENG, STACY FANG-CHING. 2008. *A Reference Grammar of Puyuma, an Austronesian Language of Taiwan*. Canberra: Pacific Linguistics Publishers.

TESTEN, DAVID. 1997. Ossetic phonology. *Phonologies of Asia and Africa (including the Caucasus)*, edited by Alan S. Kaye and Peter T. Daniels, Winona Lake, IN: Eisenbrauns, 707–731.

THACKSTON, W. M. 2006a. Kurmanji kurdish - a reference grammar with selected readings. URL: http://www.fas.harvard.edu/∼iranian/Kurmanji/kurmanji_complete.pdf.

THACKSTON, W. M. 2006b. Sorani kurdish - a reference grammar with selected readings. URL: http://www.fas.harvard.edu/∼iranian/Sorani/sorani_complete.pdf.

THOMPSON, LAURENCE C. and M. TERRY THOMPSON. 1966. A fresh look at Tillamook phonology. *International Journal of American Linguistics* 32(4):313–319.

THOMPSON, LAURENCE C. and M. TERRY THOMPSON. 1985. A Grassmann's law for Salish. *Oceanic Linguistics Special Publications, No. 20*, Honolulu, HI: University of Hawai'i Press, 134–147.

THOMPSON, LAURENCE C. and M. TERRY THOMPSON. 1992. *The Thompson Language*, *University of Montana Occasional Papers in Linguistics*, vol. 8. Missoula, MT: University of Montana.

THOMPSON, LAURENCE C.; M. TERRY THOMPSON; and BARBARA S. EFRAT. 1974. Some phonological developments in Straits Salish. *International Journal of American Linguistics* 40(3):182–196.

TIMMERS, JAN. 1974. A Sechelt text. *International Conference on Salish and Neighbouring Languages*, vol. 9, Vancouver, BC: University of British Columbia Working Papers in Linguistics, vol. 9, 10–16.

TODD, TERRY LYNN. 2002. *A Grammar of Dimili (Also Known as Zaza)*. Iremet Förlag.

TOSCO, MAURO. 1991. *A Grammatical Sketch of Dahalo*. Kuschitische Sprachstudien, Hamburg: Helmut Buske Verlag.

TOSCO, MAURO. 2000. Is there an Ethiopian language area? *Anthropological Linguistics* 42(3):329–365.

TOSCO, MAURO. 2001. *The Dhaasanac Language*. Cologne: Rüdiger Köppe Verlag.

TRAILL, ANTHONY. 1985. *Phonetic and Phonological Studies of !Xóõ Bushman*. Hamburg: Helmut Buske Verlag.

TRAILL, ANTHONY and RAINER VOSSEN. 1994. *A !Xóõ Dictionary*. Cologne: Rüdiger Köppe Verlag.

TRUBETZKOY, NIKOLAI. 1931. Die konsonantensysteme der ostkaukasischen sprachen. *Caucasica* 8:1–52.

TSUCHIDA, SHIGERU. 1976. *Reconstruction of Proto-Tsouic Phonology*. Tokyo: Institute for the Study of Languages and Cultures of Asia and Africa, Tokyo University of Foreign Studies.

TUTTLE, SIRI G. 2010. Syllabic obstruents in Ahtna Athabascan. *Rara and Rarissima: Documenting the Fringes of Linguistic Diversity*, edited by Jan Wohlgemuth; Michael Cysouw; and Orin Gensler, Berlin: Mouton de Gruyter, Empirical Approaches to Language Typology, 341–358.

TUTTLE, SIRI G. and MERTON SANDOVAL. 2002. Jicarilla Apache. *Journal of the International Phonetic Association* 32(1):105–112.

UBRJATOVA, E. I. 1966. Jakutskij jazyk. *Tjurkskie jazyki*, *Jazyki narodov SSSR*, vol. 2, edited by N. A. Baskakov, Moscow: Akademija Nauk SSSR, 403–427.

VAJDA, EDWARD J. 2009. The languages of Siberia. *Language and Linguistics Compass* 3(1):424–440.

VAN DEN BERG, HELMA. 1995. *A Grammar of Hunzib*. Ipswich, UK: Lincom Europa.

VAN EIJK, JAN. 1997. *The Lillooet Language*. First Nations Languages, Vancouver, BC: University of British Columbia Press.

VAUX, BERT. 1998. *The Phonology of Armenian*. New York: Clarendon Press.

ČUMAKINA, M. È.; D. A. DANIÈL'; M. A. DANIÈL'; JU. B. DARAGAN; N. R. DOBRUŠINA; P. V. GRAŠČENKOV; E. JU. KALININA; K. I. KAZENIN; A. E. KIBRIK; S. V. KODZASOV; E. A. LJUTIKOVA; T. A. MAISAK; A. V. SKOBELKIN; T. B. SOSENSKAJA; and C. G. TAMEVOSOV. 2001. *Bagvalinskij jazyk. Grammatika. Teksty. Slovari*. Moscow: IMLI RAN Nasledie.

VERNER, GENRIX K. 1990. *Sravnitel'naja fonetika enisejskix jazykov*. Taganrog, Russia: Taganrogskij Gosudarstvennyj Pedagogičeskij Institute.

VIDAL, ALEJANDRA. 2001. *Pilagá Grammar (Guaykuruan Family, Argentina)*. Ph.D. thesis, University of Oregon, Eugene, OR.

VIEGAS BARROS, JOSÉ PEDRO. 1993. Existe una relación genética entre las lenguas mataguayas y guaycurúes? *Hacia una Nueva Carta Étnica del Gran Chaco*, vol. 5, Las Lomitas, Formosa province, Argentina: Centro del Hombre Antiguo Chaqueño (CHACO), 193–213.

VIEGAS BARROS, JOSÉ PEDRO. 2008. Proto-lule-vilela: Una reconstrucción fonológica preliminar. Available at http://www.adilq.com.ar/Viegas-Barros.htm.

VINK, HEIN. 1977. A Haisla phonology. *International Conference on Salishan Languages*, vol. 12, Vancouver, BC: UBC Working Papers in Linguistics, vol. 12.

VISSER, HESSEL. 2013. Naro. *The Khoesan Languages*, edited by Rainer Vossen, New York: Routledge, 60–64.

VOGT, HANS. 1963. *Dictionnaire de la langue oubykh*. Oslo: Universitetsforlaget.

VOLODIN, ALEKSANDR PAVLOVIČ. 1976. *Itel'menskij jazyk*. Leningrad: Nauka.

VOSSEN, RAINER. 2013a. Kxoe subgroup. *The Khoesan Languages*, edited by Rainer Vossen, New York: Routledge, 58–60.

VOSSEN, RAINER. 2013b. Shua subgroup. *The Khoesan Languages*, edited by Rainer Vossen, London: Routledge, 71–73.

VOSSEN, RAINER. 2013c. Tshwa subgroup. *The Khoesan Languages*, edited by Rainer Vossen, London: Routledge, 73–75.

ŽUKOVA, ALEVTINA NIKODIMOVNA. 1972. *Grammatika koryakskogo jazyka*. Leningrad: Nauka.

WAGNER, EWALD. 1997. Harari. *The Semitic Languages*, edited by Robert Hetzron, London: Routledge, 486–508.

WATSON, JANET C. E. 2002. *The Phonology and Morphology of Arabic*. Oxford University Press.

WATTERS, DAVID E. 2005. Kusunda: A typological isolate in South Asia. *Contemporary Issues in Nepalese Linguistics*, edited by Yogendra Yadava; Govinda Bhattarai; Ram Raj Lohani; Balaram Prasain; and Krishna Parajuli, Kathmandu, Nepal: Linguistic Society of Nepal, 375–396.

WAYMENT, ADAM. 2009. *Assimilation as Attraction: Computing Distance, Similarity, and Locality in Phonology*. Ph.D. thesis, Johns Hopkins University, Baltimore, MD.

WAYMENT, ADAM; LUIGI BURZIO; DONALD MATHIS; and ROBERT FRANK. 2007. Harmony versus distance in phonetic enhancement. *Proceedings of the 27th Annual Meeting of the North East Linguistic Society*, vol. 2, edited by Emily Elfner and Martin Walkow, Amherst, MA: GLSA, 253–266.

WEBER, DAVID J. 1989. *A Grammar of Huallaga (Huánuco) Quechua*, *University of California Publications in Linguistics*, vol. 112. Berkeley, CA: University of California Press.

WEBER, DAVID J. 2005. *Writing Quechua: The Case for a Hispanic Orthography*, *UCLA Latin American Studies*, vol. 87. Los Angeles: UCLA Latin American Center Publications.

WELMERS, WILLIAM E. 1946. A descriptive grammar of fanti. *Language* 22(3):3–78.

WERLE, ADAM. 2007. Ditidaht vowel alternations and prosody. *The Canadian Journal of Linguistics* 52(1/2):71–104.

WIDLOK, THOMAS. 2013. Hai||om. *The Khoesan Languages*, edited by Rainer Vossen, New York: Routledge, 56–58.

WILSON, COLIN. 2006. Learning phonology with substantive bias: An experimental and computational study of velar palatalization. *Cognitive Science* 30:945–982.

WINDFUHR, GERNOT L. 1979. *Persian Grammar: History and State of Its Study*. The Hague: Walter de Gruyter.

WRIGHT, RICHARD; SHARON HARGUS; and KATHARINE DAVIS. 2002. On the categorization of ejectives: Data from Witsuwit'en. *Journal of the International Phonetic Association* 32(1):43–77.

XABIČEV, M. A. 1966. Karačaevo-balkarskij jazyk. *Tjurkskie jazyki*, *Jazyki narodov SSSR*, vol. 2, edited by N. A. Baskakov, Moscow: Akademija Nauk SSSR, 213–233.

XALILOV, M. Š. and I. A. ISAKOV. 2005. *Ginuxsko-russkij slovar'*. Maxačkala, Russia: Dagestanskij Naučnyj Centr RAN.

YAMANE-TANAKA, NORIKO. 2006. Transguttural harmony in Gitksan: Its development and typological implications. *Proceedings of the 21st Northwest Linguistics Conference*, edited by S. K. Chin and A. Fujimori, Vancouver, BC: University of British Columbia Working Papers in Linguistics, UBC Occasional Papers in Linguistics, 136–152.

YAR-SHATER, EHSAN. 1969. *A Grammar of Southern Tati Dialects*. The Hague: Mouton.

YASUGI, YOSHIHO. 1993. An areal-typological study of phonological systems of Middle American Indian languages. *Bulletin of the National Museum of Ethnology*, vol. 17, Osaka, Japan: National Museum of Ethnology (Minpaku), 627–806.

YU, ALAN C. L. 2011. On measuring phonetic precursor robustness: A response to Moreton. *Phonology* 28(3):491–518.

ZAWAYDEH, BUSHRA ADNAN. 1999. *The Phonetics and Phonology of Gutturals in Arabic*. Ph.D. thesis, Indiana University, Bloomington, IN.

ZAWAYDEH, BUSHRA ADNAN. 2003. The interaction of the phonetics and phonology of gutturals. *Phonetic Interpretation: Papers in Laboratory Phonology VI*, edited by John Local; Richard Ogden; and Rosalind Temple, New York: Cambridge University Press, 279–292.

ZEITOUN, ELIZABETH. 2007. *A Grammar of Mantauran (Rukai)*. Taipei: Academia Sinica.

ZEITOUN, ELIZABETH and CHEN-HUEI WU. 2005. Saisiyat reduplication revisited. *Concentric: Studies in Linguistics* 31(2):31–56.

ZELLOU, GEORGIA EVE. 2012. *Similarity and Enhancement: Nasality from Moroccan Arabic Pharyngeals and Nasals*. Ph.D. thesis, University of Colorado, Boulder, CO.